Spatial distribution and population structure of the mussels *Dreissena polymorpha* and *Dreissena bugensis* in the Bay of Quinte, Lake Ontario, 1998 and 2000.

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ABSTRACT

Dermott, R., Bonnell, R., Carou, S., Dow, J., Jarvis, P. 2003. Spatial distribution and population structure of the mussels *Dreissena polymorpha* and *Dreissena bugensis* in the Bay of Quinte, Lake Ontario, 1998 and 2000.

A benthic survey was undertaken in the Bay of Quinte during October 1998 to determine the density and biomass of the zebra mussel (*Dreissena polymorpha*) and the quagga mussel (*D. bugensis*) in the various parts of the bay. The Ponar grab survey was again repeated in October 2000 supplemented with diver collected samples. *Dreissena* spp. densities were much greater on gravel and bedrock above 5 m depth in the lower bay and above 3 m depth in the upper bay. Few mussels were found on soft mud in 1998 but densities increased in the upper bay on soft mud during 2000 partly due to high densities of mussels on the macrophytes. Biomass of *Dreissena* spp. was much greater in the lower bay between Glenora and Lake Ontario (4,796 g m^{-2} wet + shells) than in the upper bay between Trenton and Big Bay in 2000. Quagga mussels dominated the mussels (91%) present in the lower bay and were also common in parts of the middle bay. Almost all the mussels collected in the upper bay were zebra mussels (99%). In the upper bay, *Dreissena* average density increased from 4,712 m^2 in 1998 to 38,865 m^2 in 2000 partly due to an abundance of young mussels in October 2000.

RÉSUMÉ

Dermott, R., Bonnell, R., Carou, S., Dow, J., Jarvis, P. 2003. Spatial distribution and population structure of the mussels *Dreissena polymorpha* and *Dreissena bugensis* in the Bay of Quinte, Lake Ontario, 1998 and 2000.

Une étude de la faune benthique a été entreprise dans la baie de Quinte en octobre 1998 dans le but de déterminer la densité et la biomasse de la moule zébrée (*Dreissena polymorpha*) et de la moule quagga (*D. bugensis*) dans diverses parties de la baie. L'étude des échantillons prélevés au moyen d'une penne Ponar a été répétée de nouveau en octobre 2000 et complétée d'échantillons prélevés par des plongeurs. La densité des espèces de *Dreissena* était beaucoup plus élevée sur le gravier et la roche de fond à plus de 5 m de profondeur dans l'embouchure de la baie et à plus de 3 m de profondeur dans le fond de la baie. On a trouvé peu de moules sur la boue molle en 1998, mais la densité a augmenté dans le fond de la baie sur la boue molle durant 2000, en partie en raison de la densité élevée de moules sur les macrophytes. La biomasse des espèces de *Dreissena* était beaucoup plus élevée dans l'embouchure de la baie entre Glenora et le lac Ontario (4,796 g/m^2 de moules humides + coquilles) dans le fond de la baie entre Trenton et la baie Big en 2000. Les moules quagga dominaient les moules (91 %) présentes dans l'embouchure de la baie et elles étaient également courantes dans certaines parties du milieu de la baie. Presque toutes les moules collectées dans le fond de la baie étaient des moules zébrées (99%). Dans le fond de la baie, la densité totale pondérée de *Dreissena* a augmenté, passant de 4,712 m^2 en 1998 à 38,865 m^2 en 2000, ce qui est en partie attribuable à l'abondance de jeunes moules en octobre 2000.

INTRODUCTION

Zebra mussels (*Dreissena polymorpha*) were first discovered in Lake St. Clair during June 1988 presumably arriving there in ballast discharge from a transoceanic vessel (Hebert et al. 1989; Mills et al. 1993). They spread downstream and eastward in the Great Lakes first appearing in the Bay of Quinte in eastern Lake Ontario in 1991 (Bailey et al. 1999). About the same time a second species, the quagga mussel (*D. bugensis*), was identified amongst the zebra mussels found in Lake Ontario (Mills et al. 1993; Spidle et al. 1994). Not until 1993, two years after the zebra mussel had arrived in the Bay of Quinte, did it and the quagga mussel become common in benthic samples taken from hard substrates (Bailey et al. 1999).

The Bay of Quinte is a Z-shaped, 64-km long bay located between the town of Trenton and Indian Point where it opens into Lake Ontario (Johnson et al. 1986). The bay is divided into three sample zones for research purposes: the shallow upper zone extending from Trenton eastward past the town of Belleville to Big Bay ending at Foresters Island; the middle zone extending southward from Foresters Island near Napanee past Hay Bay to Glenora and finally the deeper, colder lower zone between Glenora and Indian Point (Johnson et al. 1986). Mid channel maximum water depths for the three zones range from 4-8 metres in the upper, 6-17 metres in the middle and increase to 17-52 metres in the lower bay (Johnson et al. 1986).

Limnologically, the upper bay is typically warm and well oxygenated during the summer months. This is due to its shallowness and mixed water column churned by the strong prevailing west wind and induced lake breezes. The middle and lower bays are also affected by wind induced mixing with additional cold water incursions from Lake Ontario reaching as far as Hay Bay (Minns et al. 1986). The lower bay remains stratified in the summer but has considerable vertical mixing from the hypolimnetic water incursions.

Zebra mussels are adapted to attach to hard substrates, where they filter algae and other particles from the water. Quagga mussels, with their different morphology, do not attach as readily to surfaces but are able to survive on softer bottom substrates. Both zebra and quagga mussels can rapidly colonise an area due to their high fecundity and a life cycle that includes a free swimming larval stage or veliger (Hebert et al. 1989).

The filtering activity of *Dreissena* has changed the energy flow to the invertebrate and fish communities of the Great Lakes by increasing water clarity, reducing algal densities and by competing against zooplankton for food (Millard et al. 1999; Johannsson et al. 2000). They have also altered the physical habitat and changed the benthic community (Coakley et al. 1997; Stewart et al. 1999; Haynes et al. 1999). The resulting increases in water transparency have increased macrophyte densities (Griffiths 1993; Skubinna et al. 1995) and altered the distribution of the light sensitive walleye which have either declined in numbers or been forced to move to deeper, more dimly lit waters (Ryan et al. 1999; J. Hoyle, OMNR, Picton, pers.comm.). Anticipating further changes to the Bay of Quinte, or predicting the trophic consequences of the mussels presence, requires an estimate of mussel abundance and biomass if predictive models are to be utilized for management strategies.

The aim of this report was three fold: 1) to compare density, biomass and the spatial distribution of zebra and quagga mussels in the Bay of Quinte between 1998 and 2000; 2) to determine the dominant species in the upper and lower bays; 3) to provide data for future predictive models on the trophic consequences of the mussels presence. To achieve these objectives a survey of the three sections of the Bay of Quinte was conducted in 1998 using a

Ponar or Ekman dredge. In 2000 the survey was again repeated using only a Ponar dredge with additional sites sampled by SCUBA divers.

METHODS

SAMPLE COLLECTION

During August, October and November 1998, 63 sites were sampled for *Dreissena polymorpha* and *Dreissena bugensis* from selected transects within the upper, middle and lower portions of the Bay of Quinte (Figure 1). Locations of these transects followed the benthic sites of Johnson & Brinkhurst 1971 and Johnson & McNeil 1986. Samples were obtained using a six inch mini Ponar grab (area 0.0225 m^2) in the middle and upper bays with a nine inch Ekman dredge (area 0.050 m^2) being used in the lower bay. At littoral sites near the shoreline, samples consisted of rocks randomly taken from a depth of 1.5 meters. In mid October 2000, all but six of the original 1998 Ponar sites were resampled using a mini Ponar grab, with 13 new Ponar sites being sampled throughout the bay (Table 1). In addition, during October 2000, 15 sites on rocky shoals were sampled by SCUBA divers using a 31.5 cm x 31.5 cm sampling frame (area 0.099 m^2). Locations of these dive sites were from an earlier Ontario Ministry of Natural Resources (OMNR) whitefish spawning survey (Hoyle & Melkic 1991; Ted Schaner, OMNR, Picton, pers.com.). Site locations based on Global Positioning System (GPS) coordinates are listed in Table 1 for the 1998 and 2000 mini Ponar surveys. The GPS coordinates for the fall 2000 dive samples are given in Table 2.

Mini Ponar/Ekman Sampling

Two replicate grabs were collected at all the Ponar and Ekman sites (Table 1). The samples were washed on a US standard # 30 mesh (600 μm mesh) screening bucket, rinsed onto a #80 mesh (180 μm) sieve then transferred into 500 or 1000 ml Mason jars. Samples were initially preserved in 8-10 % neutral formalin which was later removed and replaced with 50% isopropyl alcohol.

In the laboratory, the preservative was decanted and the samples separated into macrophyte and non-macrophyte portions. The non-macrophyte portion was washed on a #80 mesh sieve with tap water then re-sieved through a 1 mm mesh screen to remove newly settled mussels <1 mm in length. Mussels on the surfaces of macrophytes were carefully removed and also sieved through a 1 mm sieve to remove newly attached mussels <1 mm in length. Mussels remaining on this sieve were then added to the non-macrophyte portion. These combined portions of mussels, retained on the 1 mm mesh, were then identified as either zebra or quagga mussels, sorted into five size groups for each species based on length, and enumerated. For each size group (<5, 5-10,10-15,15-20, >20 mm) biomass was measured as wet weight with shells by blotting the mussels on filter paper to remove excess water and weighing to the nearest 0.01 milligram. The mussels <1 mm were not examined but added to the remaining invertebrates and debris material preserved in the original jars. The only other invertebrate enumerated was the mayfly *Hexagenia*. Blotted wet weight of the macrophytes was measured only in mini Ponar samples, neither macrophytes nor *Hexagenia* were sampled at the dive samples.

Littoral Sampling

Littoral samples were obtained by randomly collecting rocks from a depth of approximately 1.5 m at three selected sites in the Bay of Quinte (Table 1). The rocks were placed mud side down on a flat surface and a 6.5 cm diameter ring (1/301 m^2) was then positioned randomly over the rock's upper surface. Any mussel within this quadrate was removed with a spatula, placed on a tray and enumerated to determine density. Counts from a minimum of 20 of these quadrates were obtained from each littoral site. At each site, the first one hundred mussels collected were placed in a paper bag and allowed to air dry. In the laboratory these air dried samples were separated by species, enumerated and measured to determine length-frequency distributions and dry weight relationships for each genera. Biomass was weighed as dry weight values (with shells) to the nearest milligram. Dry biomass was converted to wet weight with shell from ratios of dry/wet mass for each mussel species.

Dive Sampling

Benthic samples were collected using a "L" sampling pattern technique devised by the Ontario Ministry of Natural Resources at locations previously used for a whitefish spawning survey (Figure 2). Several of these dive sites were also sampled with a mini Ponar to allow for a comparison of diver versus mini Ponar sampling methods.

Upon arrival at the GPS located site, the divers tossed a sample frame (area 0.099 m^2) with one edge painted white, onto the substrate. The diver recorded the estimated area of dominant substrate and apparent secondary substrate within the frame using the following five categories: bedrock, cobble/rock rubble, gravel/ mussel clumps, large debris or sand/mud. The initial quadrate was designated as dive sample 1 (D-1). The first frame and subsequent frames marked potential sample quadrates. The next quadrate was found by flipping the highlighted side of the frame end over end four times. Samples used in this study were obtained from quadrate frames 1, 2, 5, 9 and 10. Sampling proceeded as above for each chosen quadrate. At sample quadrate 5 the frame was turned 90° and placed back onto the bottom thus shifting the next five quadrates 90° from the first five (Figure 2).

Small rocks and/or sticks inhabited by mussels within the sample frame were collected, placed in a labeled plastic bag and taken to the surface. If the frame covered large cobble, only one representative rock was collected from inside the frame and placed in a bag. In the case of bedrock or dense bottom mussel coverage, a 10 cm x 10 cm area of mussels was scrapped off and placed in a labeled plastic bag. On shore, the samples were transferred from the dive sample bags to Mason jars. If the dive bag contained a rock sample, the rock was scrapped to remove all mussels and these mussels placed in a Mason jar. The scraped rock was labelled and kept for surface area determination. Mussel clumps or encrusted sticks were broken up in order to fit in a Mason jar. The mussels were preserved in approximately 10% neutral formalin.

In the laboratory, the formalin supernatant was decanted and each sample washed onto a #80 mesh sieve with tap water then re-sieved through a 1 mm mesh screen. Mussels retained on the 1 mm screen were stored in 50% isopropyl alcohol. The samples were later identified as either zebra or quagga mussels, enumerated and sorted into size classes.

Surface area of rocks, collected by the divers, was measured using an aluminum foil area:weight relationship technique. Precisely measured squares of aluminum foil were weighed to the nearest 0.1 mg to develop an area:weight relationship (Figure 3). The calibrated foil was then used to cover the entire surface of the dive sample rock with no overlap, carefully removed, weighed and the area for each rock calculated. The exposed footprint (top and exposed sides) of each rock was assumed to be 0.33 of the total surface area. The densities of mussels in the dive samples were calculated based on either: 1) footprint area of rock multiplied by the estimated percentage area of cobble substrate on bottom; 2) total sampled quadrate area; or 3) the smaller 10 x 10 cm sub sample area. The data from the dive sites were converted to m^2 for comparing all data from the various sites and listed in the appendices as "Ponar equivalent area".

RESULTS

During 1998, density and biomass of *Dreissena* spp. were much greater in the lower Bay of Quinte, east of Glenora, than in the upper bay, west of Foresters Island (Table 3). Average density in the lower bay was 20,106 m^{-2} which was about four times greater than the density in the Trenton area of the upper bay (5,263 m^{-2}). Average density of the 64 samples collected from the upper bay during 1998 was 4,712 m^{-2}. The biomass of *Dreissena* averaged 2,893 g m^{-2} (wet + shells) in the lower bay, which was almost seven times the mussel biomass in the Trenton area (Table 3). *Dreissena* biomass in the upper bay averaged 981 g m^{-2} in 1998.

The density of mussels had increased greatly in the upper and middle bays by October 2000 compared to the density in those areas in 1998 (Tables 3 and 4). Average density in the combined 96 Ponar and dive samples from the two upper bay zones (n=55+41) in 2000 was 38,865 m^{-2}. *Dreissena* density in the lower bay (25,769 m^{-2}) was only about 1.5 times that in the upper bay (Table 4). Data from all samples (dive + Ponar grabs) in 2000 showed little variation in mussel density between the different areas of the Bay of Quinte as compared to the greater variation in 1998 (Figure 4). Unlike in 1998, total *Dreissena* wet biomass in the lower bay in 2000 (4,796 g m^{-2}) was only 1.4 and 3 times greater than the mussel biomass in the Belleville Bay and Trenton areas of the upper bay respectively. Wet biomass of the 96 combined samples in the upper bay during 2000 averaged 2,684 g m^{-2} with shells (Table 4). Biomass increased throughout the bay in 2000 showing less variation than in 1998 (Figure 5).

COMPARISONS 1998 versus 2000

Statistical comparisons of total density and biomass were made using the 1998 data and only the data from the 2000 Ponar samples (Table 5). The 2000 dive samples were omitted from this analysis to prevent bias caused by different collection methods. The inter-site variability in density, as natural log transformed values, was less in 2000 than in 1998 but variability between replicates at each site remained similar (Figure 6). There was a significantly greater difference in inter-site density ($p<0.02$) than inter-year density in the Bay of Quinte ($p<0.05$; Table 6a). The inter-site difference in density was greater in 1998 than in 2000 ($p<0.05$ versus $p>0.5$). The log transformed biomass showed very similar inter-site trends in 1998 and in 2000 (Figure 7). The year to year difference in total *Dreissena* biomass ($\log_n$ transformed) was highly significant

(p<0.001), the inter-site differences in biomass were also significant (p<0.05). There was greater inter-site difference in biomass in 2000 (p<0.001) than in 1998 (p<0.05 ; Table 6a).

In 1998, mussel biomass in the Conway area was significantly greater than the Trenton area of the upper bay but no significant difference was found between the other areas of the bay (Table 6b, Figures 5 and 7). In 2000, the biomass was very significantly different between Trenton versus both the Glenora and Conway areas of the lower bay (p<0.0001). Biomass of total mussels was also different between the lower bay areas of Conway and Glenora versus the middle bay area of Napanee in 2000 (Table 6b). There was no difference between biomass at Conway compared to Glenora or the middle bay compared to the upper bay (Figure 7).

Densities were highly variable in both the Ponar and dive samples. The Ponar grab tended to collect slightly fewer mussels or have less biomass than the dive samples. This was more evident at the shallower sites in the lower bay (Tables 4 and 5). However statistical comparison of density and biomass in diver versus Ponar collected samples at the same sites showed there was often little difference due to the very large variability in the replicate samples (Table 7). At the four sites compared, t-tests indicated that only biomass was significantly greater in the dive samples than in the Ponar samples at two sites, Conway 3m and Conway 8m (Table 7). Differences in density were not significant (t values <1.8).

Quagga mussels (*Dreissena bugensis*) were very rare in the upper bay during 1998, but were more common in the middle bay between Foresters Island and Hay Bay (Long Reach). Quagga mussels were much more abundant than zebra mussels (*D. polymorpha*) in the lower bay during 1998 (Table 3). The density of quagga mussels became greater in the Belleville-Big Bay area of the upper bay in 2000 compared to 1998 but their density remained similar in the Trenton area. Quagga mussels remained less than 0.1% of the total *Dreissena* collected in the upper bay in 1998 and 2000. Although their density remained similar in the middle bay, the proportion of quagga mussels actually decreased in the middle bay from approximately 50% in 1998 to 5% of the mussels collected during 2000 (Table 8). In parts of the lower bay, quagga mussels made up to 99% of all the mussels collected in 2000. There was a slight increase in the proportion of quagga mussels in the deeper (>5 m), coolers water of the lower bay in 2000 (Table 8).

COMPARATIVE AVERAGE SIZES

The *Dreissena* population in the upper Bay of Quinte during 2000 was heavily dominated by young, newly settled mussels with shell lengths <5 mm which represented between 65 and 94% of the population in the upper bay (Table 9). This young population was more prominent among the zebra mussels than the quagga mussels in the middle and lower bays. Normally in the Bay of Quinte, mid summer reproduction results in settlement of the young by late August. By October most of the mussels which had settled in the summer would have grown to about 5 mm.

The lower bay population was dominated by larger mussels >5 mm which formed 77.6% of the population, but over 84% of the zebra mussels collected in the shallow depth zone of the lower bay were less than 5 mm in length (Table 9). The proportion of young quagga mussels <5 mm in the middle and lower bays was much less than the proportion of young zebra mussels. The larger quagga mussels in the middle and lower bays were either faster growing or more likely older than the zebra mussels. Very few young existed in the depth zone beyond 20 m where only 3.8% of the quagga mussels were <5 mm in length (Table 9). Mean individual wet biomass of the

quagga mussels, in the upper and middle bays, was greater than 461 mg/individual compared to a mean individual wet biomass of 32.6 to 121.7 mg/individual for the zebra mussels in the upper and middle bays.

SIZE FREQUENCY OF THE POPULATIONS

Upper bay

The size frequency of the mussels varied by depth and year. In October 1998, at a transect in the upper Bay of Quinte at Big Bay (U14), the zebra mussel population living at a littoral site of <1.5 m depth had a unimodal size of 15 mm. Offshore, the mussels living at 4 m depth had three length peaks of 4 mm, 12 mm and 25 mm representing older and much larger mussels surviving in deeper water (Figure 8). These would represent up to three age classes due to either three settlement periods or mussels from three different years. In October 2000, at the same transect, very few of the larger zebra mussels survived (Figure 9). The population at all depths along the transect was dominated by zebra mussels <7 mm, with animals >13 mm probably representing a few individuals with ages greater than 1 year. Growth over the summer was apparently greater at the littoral site (1m) than at the 2 and 3 m sites along the transect (Figure 9).

Size frequencies also varied by location in the upper bay. In October 1998, zebra mussels at a littoral site (depth <1.5m) near Trenton (U4-01) had a definite bimodal size distribution suggesting either two settlement events or a population of two year classes (Figure 10). This was quite different from the unimodal population at the Big Bay littoral site (U14-01). The size frequency at the exposed site U14-01 in 1998 suggested rapid growth to an average length of 15 mm over the summer (Figure 10). The presence of larger mussels of 25 mm shell length at site U10-1 in 1998 indicates good over-winter survival of mussels that had settled in 1997 or earlier at this protected site in a small bay near the narrows between Belleville and Big Bay (Figure 10).

In October 2000, the size frequencies suggested that only one age class dominated the populations at all three littoral sites (Figure 11). Size frequencies in 2000 were more similar at the littoral sites, with modal length slightly greater at the Trenton littoral site (U4-01) than at the other two sites. The larger zebra mussels that were at shallow littoral site U10-01 in 1998 had disappeared due to either over-winter mortality or post-reproductive stress.

Size frequencies at slightly deeper sites in the upper bay indicated a wider range in size. At two sites within 3.5 km of each other, the first site (U1-05) had little change in inter-year size frequency between 1998 and 2000 (Figure 12). However, a 12 mm difference in modal length occurred at a second site (U3-01) between October 1998 and October 2000.

Lower bay

At the deeper sites in the lower Bay of Quinte, the size frequency of the *Dreissena* spp. tended to be more similar from year to year than in the upper bay. At site T-4F and T-4E in 5 and 15 m depth respectively, large quagga mussels of 25 mm were present in both 1998 and 2000 (Figure 13). In the lower bay, zebra mussels were more common at shallower depths than beyond 15 m, and where they occurred, zebra mussels had a different modal size than the quagga mussels. At site T-4F, two age (year) classes of zebra mussels were present in 1998 but only one was present in 2000 (Figure 13). At site T-9F zebra mussels were present in 1998 but

absent in 2000 (Figure 14). Although the size frequency of the quagga mussels remained very similar in 1998 and 2000 at most sites in the lower bay, the quagga mussels at T-9D in 21 m depth had a very different unimodal size frequency in 1998 compared to that in 2000 (Figure 14). Size distributions in the lower bay suggest that three summers may be required for the quagga mussels to grow to beyond 20 mm length at depths below 8 m.

HISTORICAL DENSITY

Dreissena spp. became common in the Bay of Quinte in 1993. Density of mussels was monitored at three littoral sites (<2 m depth) for several years. These sites were at Amherst Island at the entrance to the bay, site U14-01 in Big Bay and site U4-01 near Trenton. Density on the cobbles in the littoral zone is easily measured and provides the number of mussels that settle, an index of reproductive success and growth over the summer. However, the littoral zone is marginal habitat for *Dreissena* over the winter because of extensive mortality from ice scour and winter storms. Both mussel species first appeared in the lower bay at the Amherst Island site in 1993 (Table 10a). Although mid summer density at Amherst Island remained similar in magnitude between 1994 and 1996, when sampled over the summer of 1995, density increased from 409 to 2,764 m^{-2} (July to October). Density above 2 m depth was less than below 2 m in July 1995 (409 versus 1,080 m^{-2} respectively). At the Big Bay littoral site, density of zebra mussels increased greatly between 1994 and 2000. Large increases occurred over the summers of 1995 and 1998 at this site, but winter mortalities were high as shown by the large decreases that occurred between October 1995 and May 1996 as well as between October 1998 and August 1999 (Table 10a).

At sites in the deeper and more stable lower Bay of Quinte environment, mussel density at a depth of 21 m increased from 20 m^{-2} and 130 m^{-2} in July 1994 to between 960 m^{-2} and 2,380 m^{-2} in 1998 respectively (Table 10b). Although density remained similar between 1998 and 2000 at these sites, the biomass increased greatly between 1998 and 2000 (Table 10b) as the established population aged. Mussel biomass is a surrogate of their volume and is thus a better indicator of the filtering capacity of the population than is their density.

PLANT versus *DREISSENA* BIOMASS

In the Bay of Quinte, the abundance of macrophytes has increased as a result of increasing water clarity. At many sites in the upper bay, macrophytes were present in the Ponar samples and often the plants had numerous attached mussels, up to 438,030 m^{-2} (Figure 15). Several of the aquatic plants, especially *Elodea canadensis*, *Ceratophyllum demersum* and some of the *Potamogeton* species were good substrates for the attached zebra mussels.

Regression between mussel density and plant biomass was weak (r^2 = 0.35; Figure 15). This was partly due to several of the plant species rarely having attached mussels, such as the limp leaves of *Vallisneria spiralis* and the often dense milfoils *Myriophyllum* spp.. However, when the two outlier samples with the greatest plant biomass were removed from the regression, the correlation greatly increased (r^2 = 0.84). Regression between mussel biomass and plant biomass was poor (r^2 = 0.13 with all the data), and improved to only 0.25 when the two outlier samples were removed (n=24) from the analyses.

The young attached mussels (normally <5 mm long) could survive the summer on the plants until their weight either collapsed the plants, or the plants died back in the autumn. It is unlikely many of the mussels attached to the plants survived over winter on the mud substrate after the plants decomposed.

HYPSOGRAPHIC DENSITY

The two dimensional plane of the surface area of the upper bay was hypsographically corrected to reflect the actual submerged contours in the bay. Surface areas for each of the depth contours in the upper Bay of Quinte (between Trenton and the narrows east of Big Bay) are listed in Table 11. Maximum depth in the Trenton area is 6 m, but most of the upper bay is between 3 and 5 m. Although maximum depth in the Belleville - Big Bay section of the bay is 11 m, the area beyond the 7 m contour is very small. Total hyposographic area of the upper bay section was 110.27 km^2. These hyposographic areas were used to calculate the total *Dreissena* biomass in the upper Bay of Quinte based on population biomass for the 0 to 3, 3.1 to 5 and >5.0 m contours.

Most of the *Dreissena* biomass in the upper bay was in the 0 to 3 m contour (57%), except in 2000 where there was an almost equal biomass above and below the 3 m contour in the Belleville-Big Bay section. Total *Dreissena* biomass in the upper bay increased from 108.17×10^3 Tonnes (wet shells-on) in 1998 to 268.85×10^3 Tonnes in 2000 (Table 12). Averaged over the upper bay area, the mussel biomass was 0.98 and 2.34 kg m^{-2} (wet weight + shells) respectively in 1998 and 2000. The production of this amount of mussel tissue puts a huge strain on the algal production of the bay.

HEXAGENIA DENSITY

Abundance of the burrowing mayfly *Hexagenia* was also recorded when they occurred in the Ponar samples. This mayfly was only found in samples from the middle and lower bays, with greatest density occurring at a depth of 15 m at site T-4E in 1998 (Table 13). In 2000, *Hexagenia* were only seen in samples from site T-4E. *Hexagenia* had been common in the Bay of Quinte historically but they had disappeared from the upper bay by 1966 and were not reported by Johnson & Brinkhurst (1971).

DISCUSSION

Most of the bottom substrate in the upper Bay of Quinte, at depths >3 m, consists of a soft black mud. This substrate is easily re-suspended by storms thus smothering mussels which settle on it. As a result near Trenton, at depths deeper than 3 m, mussel density was between 5 and 150 m^{-2} in 1998 and 2000 respectively. The cobble and gravel substrate in the littoral zone at depths less than 2 m was good summer habitat for newly settled mussels, but not suitable over-wintering habitat due to ice scour and unstable bed during strong fall and winter storms. For those reasons, *Dreissena* density varied greatly from year to year at the littoral sites sampled thus reflecting summer reproduction and not a true measure of the adult population of the bay. Most of the mussels which survive the winter in the upper Bay of Quinte were those that settled in a narrow band of hard habitat between 2 and 3 m depths on bedrock, gravel, logs, docks and on the few rocky shoals such as Makatewis Shoal.

The abundance of settling mussels and timing of their settlement depends on the reproductive season and the location of the drifting veligers just before the time of settlement. Spawning peaks can be bimodal in summer or just once per year depending on local water temperatures and condition of the adults (Garton and Haag 1993), thus both density and size frequency of the mussels varied greatly at nearby sites (of similar depths) and from year to year. In the upper bay, density in water of less than 3 m depth averaged between 5,860 m^{-2} in 1998 to over 51,119 m^{-2} in 2000. Depending on depth, average density of *Dreissena* spp. in the lower bay varied from 1,361 to 58,890 m^{-2}. This range was comparable to densities in eastern Lake Erie which had an average of 4,800 m^{-2} on soft mud and up to 68,000 m^{-2} on rocky shoals (Jarvis et al. 2000)

Healthy expanding macrophyte beds have returned to the Bay of Quinte following the increase in water clarity (Kathy Seifried, Fisheries and Oceans Canada, Burlington, pers.com.). The dense macrophyte beds form a vast but temporary substrate for the mussels. In late summer, densities of young mussels less than 5 mm long were up to 438,030 m^{-2} attached to the aquatic plants in the Trenton and Belleville areas. In late autumn, most of the attached zebra mussels die as the plants sink to the bottom and rot. Despite this, the high fecundity of the surviving mussels in the bay ensure colonization of the plants the following summer. A weak regression between mussel density and plant biomass is partly due to several of the common macrophytes species not being able to support the weight of the attached mussels or, where macrophyte beds are dense, restricted currents may prevent uniform settlement of the post-veliger young on the plants.

The dominance of quagga mussels in the cool, deep waters of the lower bay and their rarity in the warm, shallow waters of the upper bay is also a phenomenon found in eastern Lake Erie and Lake Ontario (Jarvis et al. 2000; Mills et al. 1999). Navigational buoys in the Bay of Quinte examined in December of 1992 had no mussels attached (Wormington et al. 1993). A year later, in December 1993, zebra mussels were present on only 11 of the 31 navigational buoys in the Bay of Quinte at densities < 125 m^{-2}. Two years later, in December 1994, all the buoys had attached zebra mussels but only the buoys from near the entrance to Lake Ontario had attached quagga mussels (Wormington et al. 1995). The poorer ability of quagga mussels to attach to objects was also shown by their sparse attachment to macrophytes (Diggins et al. 2002). In 2000, less than 5% of the mussels found in the warm waters between Hay Bay and Trenton were quagga mussels, conversely over 90% of the mussels in the cool, lower bay were quagga mussels. Quagga mussels appear to be more energy efficient in cooler, more oligotrophic conditions than the zebra mussels (Baldwin et al. 2002) and would thus survive better in the clearer water of the lower bay. The net downstream current from the main tributaries entering the upper bay may also prevent quagga mussel veligers from drifting from the lower bay into the upper bay above Foresters Island. Inflows of Lake Ontario water have been tracked up the bay as far as Hay Bay in the middle bay (Robinson 1986), possibly transporting the quagga mussel veligers into the middle bay.

Both mussel species are responsible for the increased water clarity in the Bay of Quinte as they remove algae and silt from the water. The larger and older quagga mussels in the lower bay resulted in a biomass averaging 4.79 kg m^{-2} (wet + shells) but the biomass was as great as 5.86 kg m^{-2} near Glenora. The comparable hypsographic average biomass in the upper bay was 2.44 kg m^{-2} (Figure 5 and Table 12). As the percentage of soft tissue in the total live wet weight was about 56% for zebra mussels and 58% for quagga mussels (Johannsson et al. 2000), the wet shell-free biomass in the upper bay would be about 1.36 kg m^{-2} and perhaps as high as 2.78 kg m^{-2} wet mussel soft tissue in the lower bay.

If the percentage of dry weight is 12% and 8% for the zebra and quagga mussels respectively and the shell free dry tissue was assumed to be 89% ash free dry weight (AFDW), then the *Dreissena* AFDW would have been 0.146 kg m^{-2} in the upper bay and 0.200 kg m^{-2} AFDW in the lower bay in October 2000.

Using an annual production to biomass ratio (P/B) of 1.39 (Chase and Bailey 1999), production in the upper bay would have been 0.203 kg AFDW $m^{-2} yr^{-1}$ and 0.275 kg $m^{-2} yr^{-1}$ AFDW in the lower bay. The product to ingestion ratio (P/I) of 0.131 for *Dreissena* in Lake Esrom (Hamburger et al. 1990) assumed a low assimilation efficiency (A.E.) of 0.5. Using a calculated A.E. of 0.6 (Schneider at al. 1998; Baldwin et al. 2002) the P/I ratio would be 0.159; then the consumption by the mussel population in the upper bay may have been 1.28 kg $m^{-2} yr^{-1}$ AFDW in 2000, and in the lower bay up to 1.73 kg $m^{-2} yr^{-1}$ AFDW. The P/B ratio of old slow growing populations found in the lower bay may be only 0.57 (Hamburger et al. 1990) resulting in a *Dreissena* production in the lower bay of only 0.114 kg $m^{-2} yr^{-1}$ AFDW.

Bailey et al. (1999) estimated the mussel population in the Bay of Quinte could potentially filter all the available phytoplankton in 0.05, 0.2 and 10 days for the upper, middle and lower bay respectively. However their calculated density of 500 m^{-2} at depths greater than 15 m was about 1/3 the density in the lower bay during 2000. They calculated the filtering impact in the Bay of Quinte was 3 to 5 order of magnitude greater than the estimated turnover time in Lake Ontario. Seasonally, the habitat provided by plants also greatly expands the filtering impact the mussels have on the upper Bay of Quinte. In addition to this domination of the energy flow of the bay, the *Dreissena* alter habitat with the presence of their shells, (Coakley et al. 1997; Stewart et al. 1999), increase water clarity and light penetration (Leach 1993), alter algal communities (Vanderploeg et al. 1996) and influence the benthic community associated with their colonies (Haynes et al. 1999; Strayer and Smith 2001).

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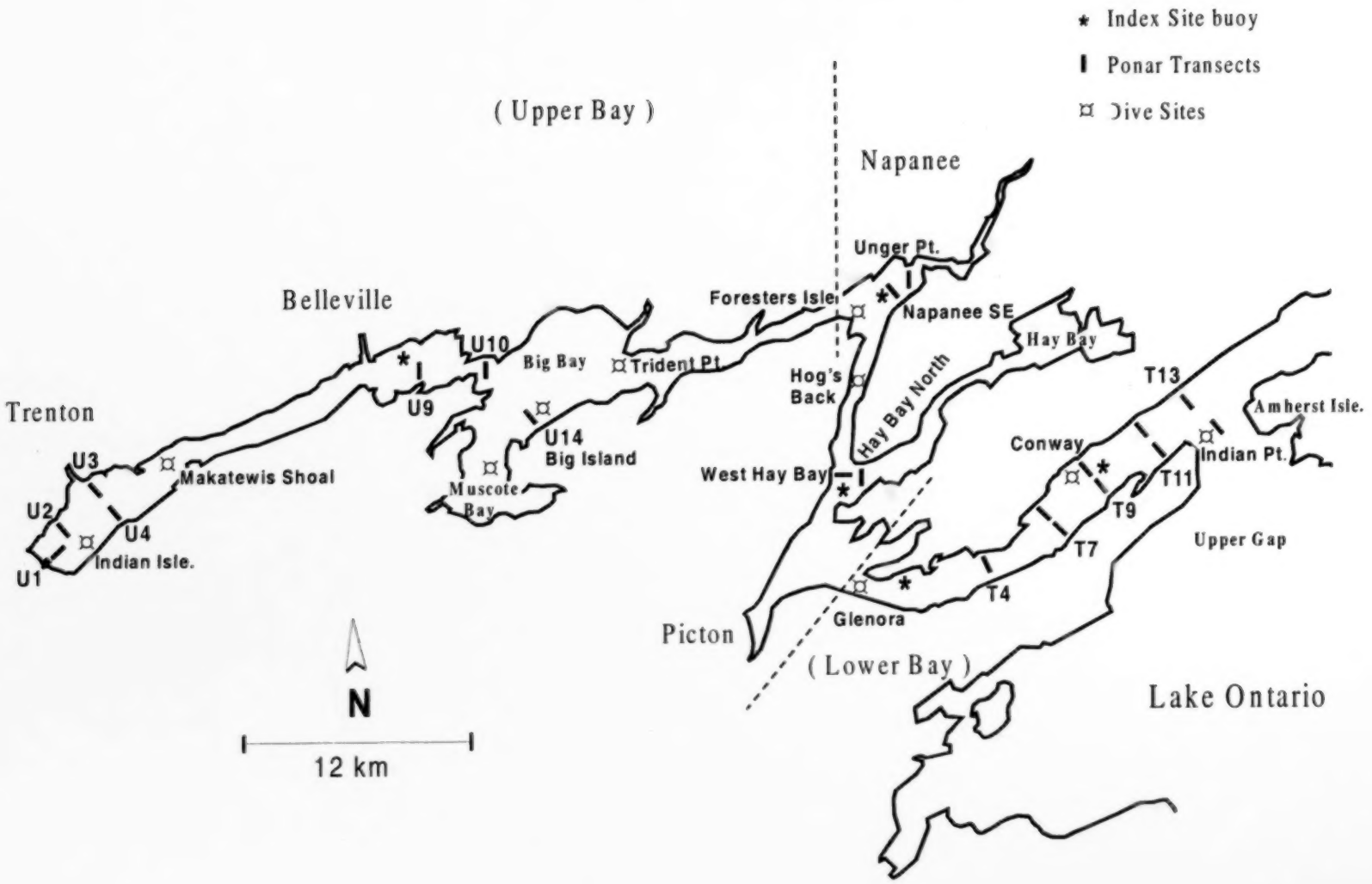

Figure 1. Location of Ponar and dive sites for 1998 and 2000 benthic surveys.

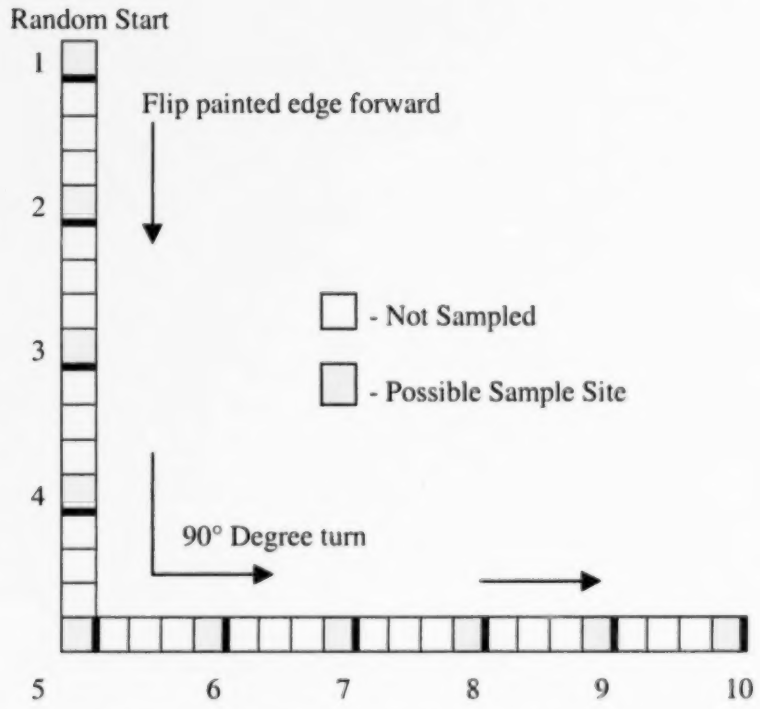

Figure 2. "L" sample pattern used for diver collected samples.

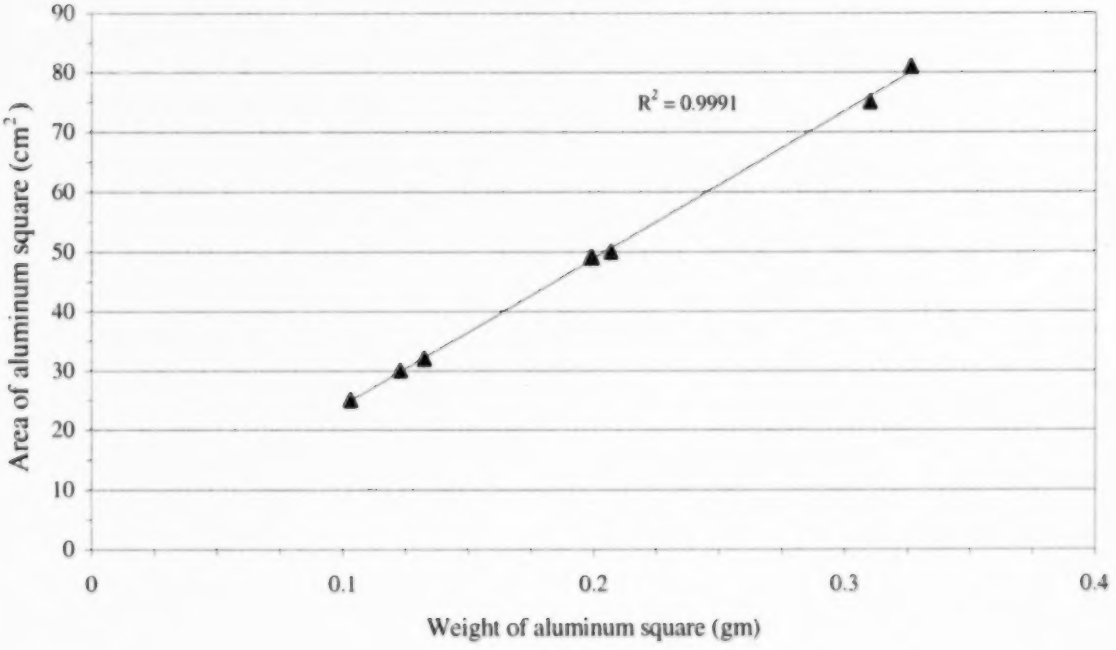

Figure 3. Area to weight ratio of aluminum foil (0.025 mm thick).

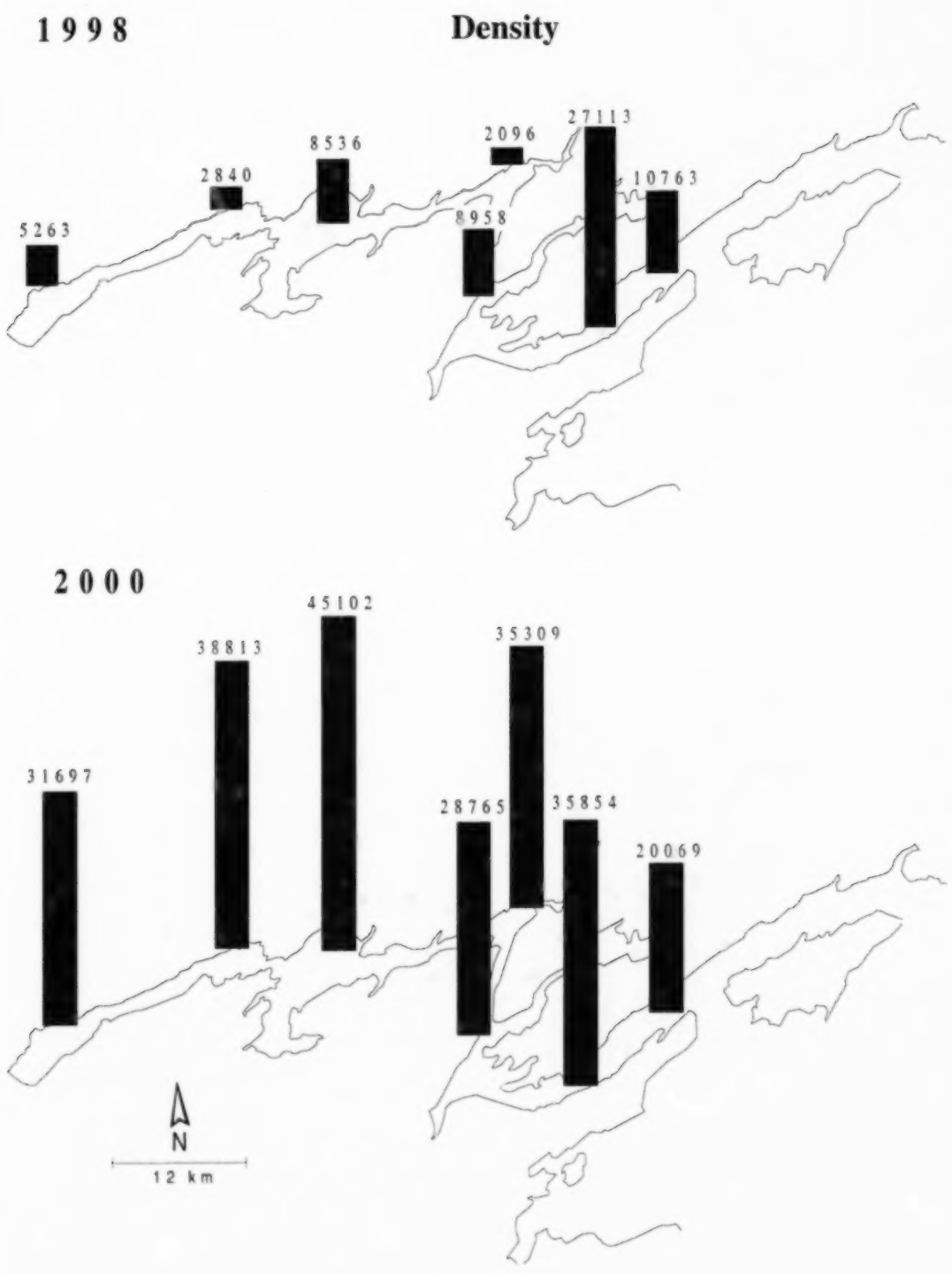

Figure 4. *Dreissena* spp. density (no./m^2) during 1998 and 2000 in the Bay of Quinte. Data from all Ponar and dive samples.

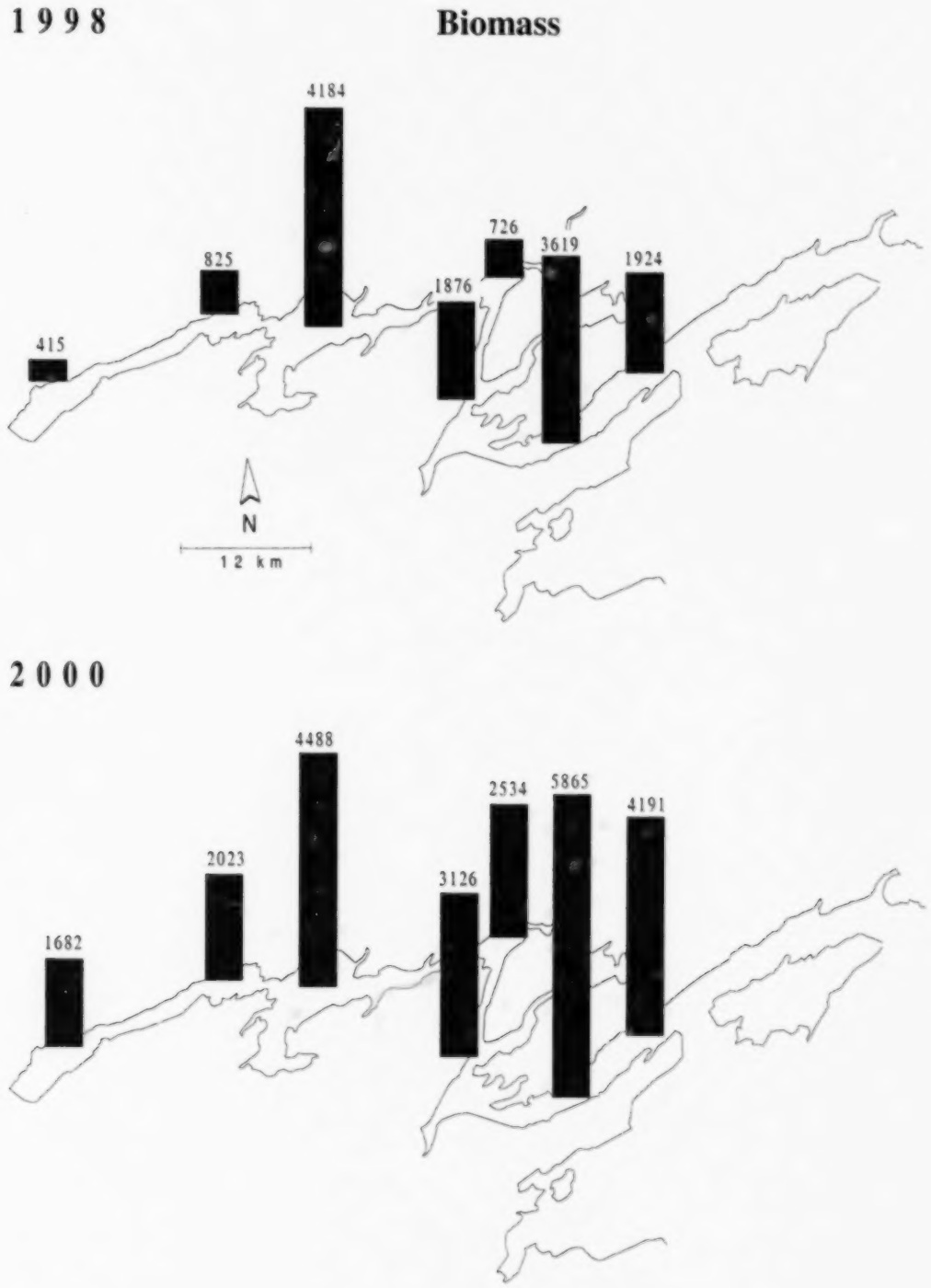

Figure 5. 1998 and 2000 *Dreissena* spp. biomass (g/m² wet weight with shells) for the Bay of Quinte, data from all Ponar and dive samples.

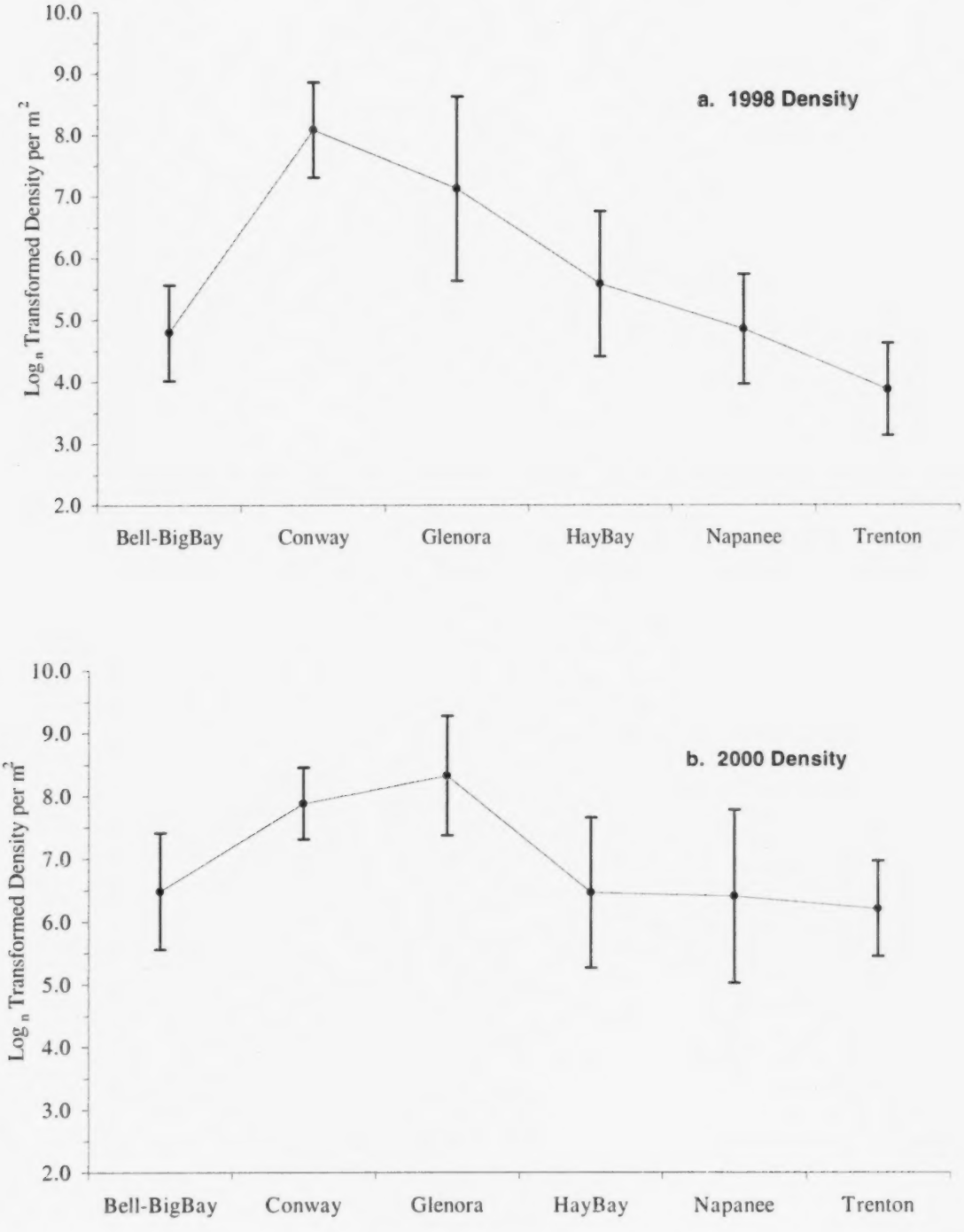

Figure 6. Log $_n$ transformed density and Standard Error of *Dreissena* spp. in areas of the Bay of Quinte in 1998 and 2000 (only Ponar samples compared).

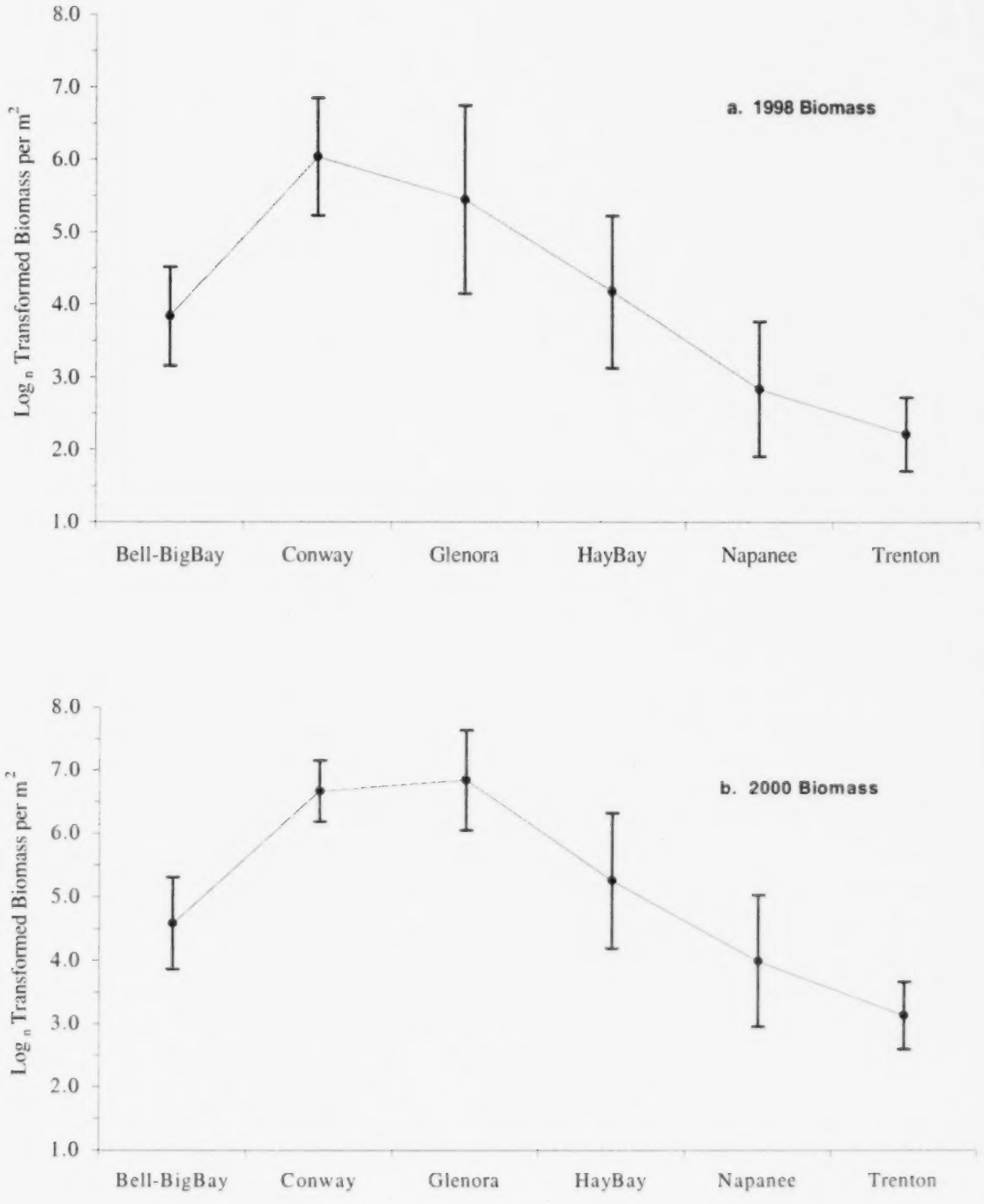

Figure 7. Log $_n$ transformed biomass and Standard Error of *Dreissena* spp. in areas of the Bay of Quinte in 1998 and 2000 (only Ponar samples compared).

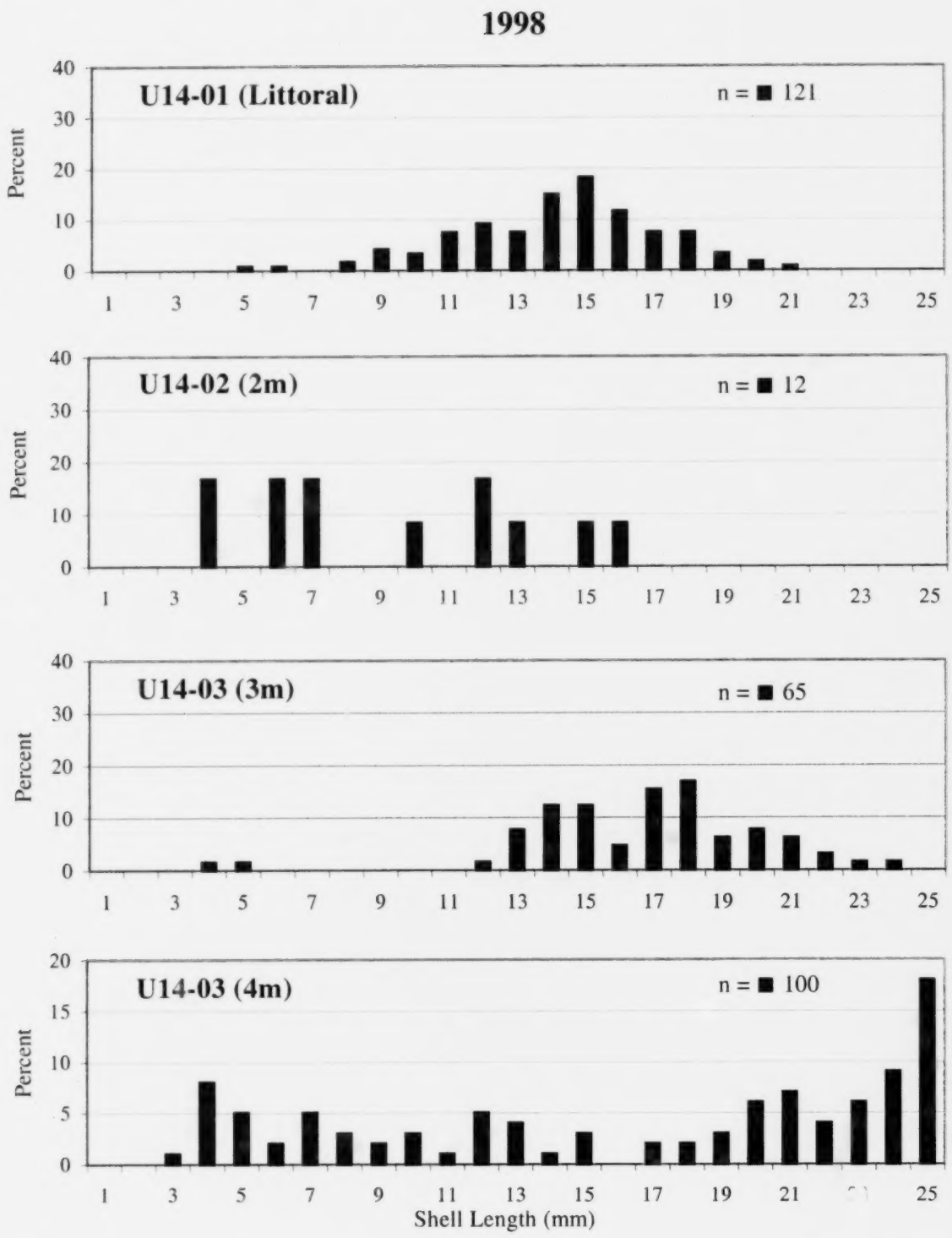

Figure 8. Length frequency of *Dreissena* spp. at sites along Big Bay transect U14 in the Upper Bay of Quinte during 1998.

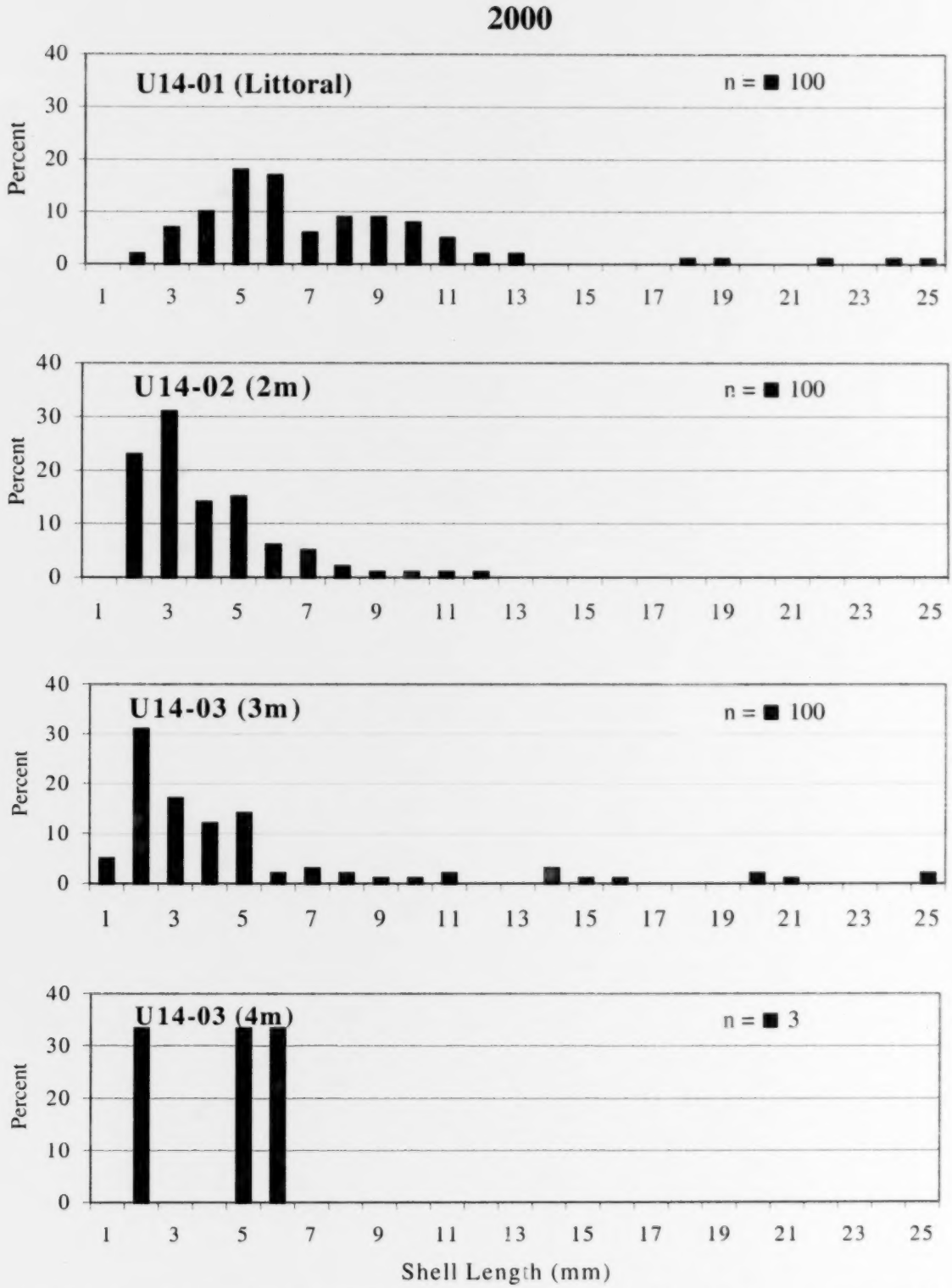

Figure 9. Length frequency of *Dreissena* spp. at different depths along Big Bay transect U14 in the Upper Bay of Quinte during 2000.

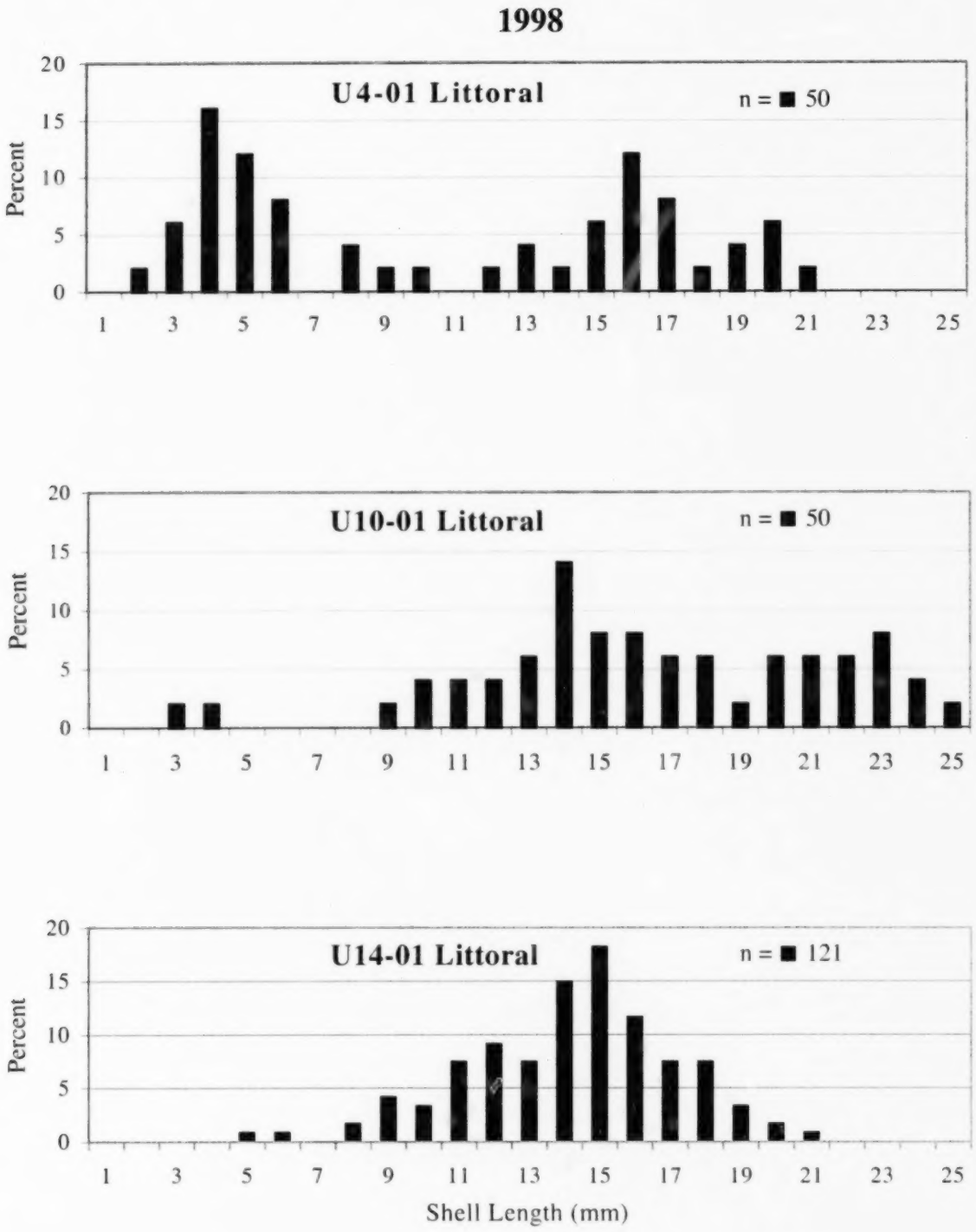

Figure 10. Comparison of length frequency of *Dreissena polymorpha* at three Upper Bay of Quinte littoral sites in 1998 at depths < 2m.

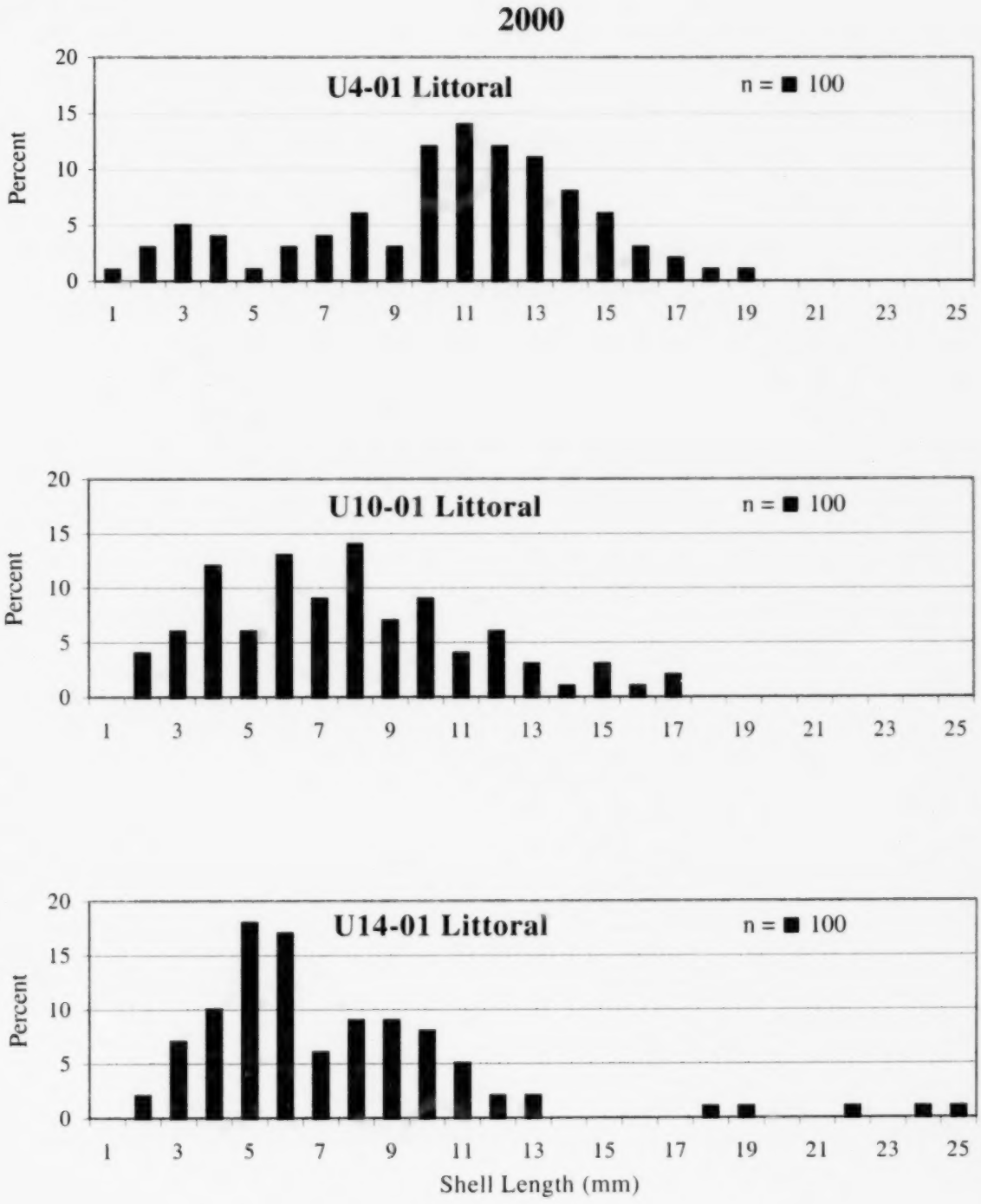

Figure 11. Comparison of length frequency of *Dreissena polymorpha* at three Upper Bay of Quinte littoral sites in 2000 at depths < 2 m.

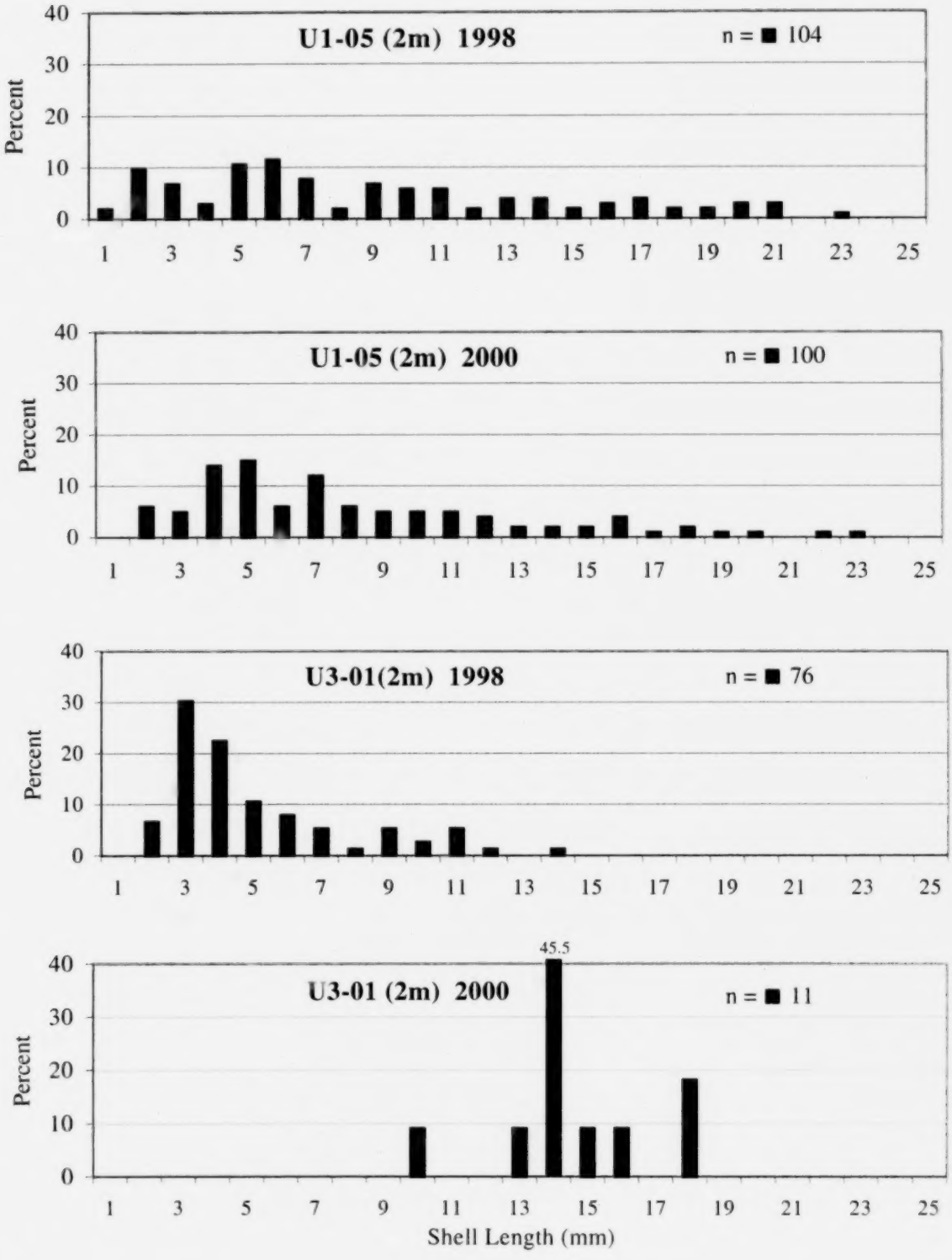

Figure 12. Comparison of length frequency of *Dreissena* spp. at two Upper Bay of Quinte transects U1 and U3 in 1998 and 2000 both 2 m deep.

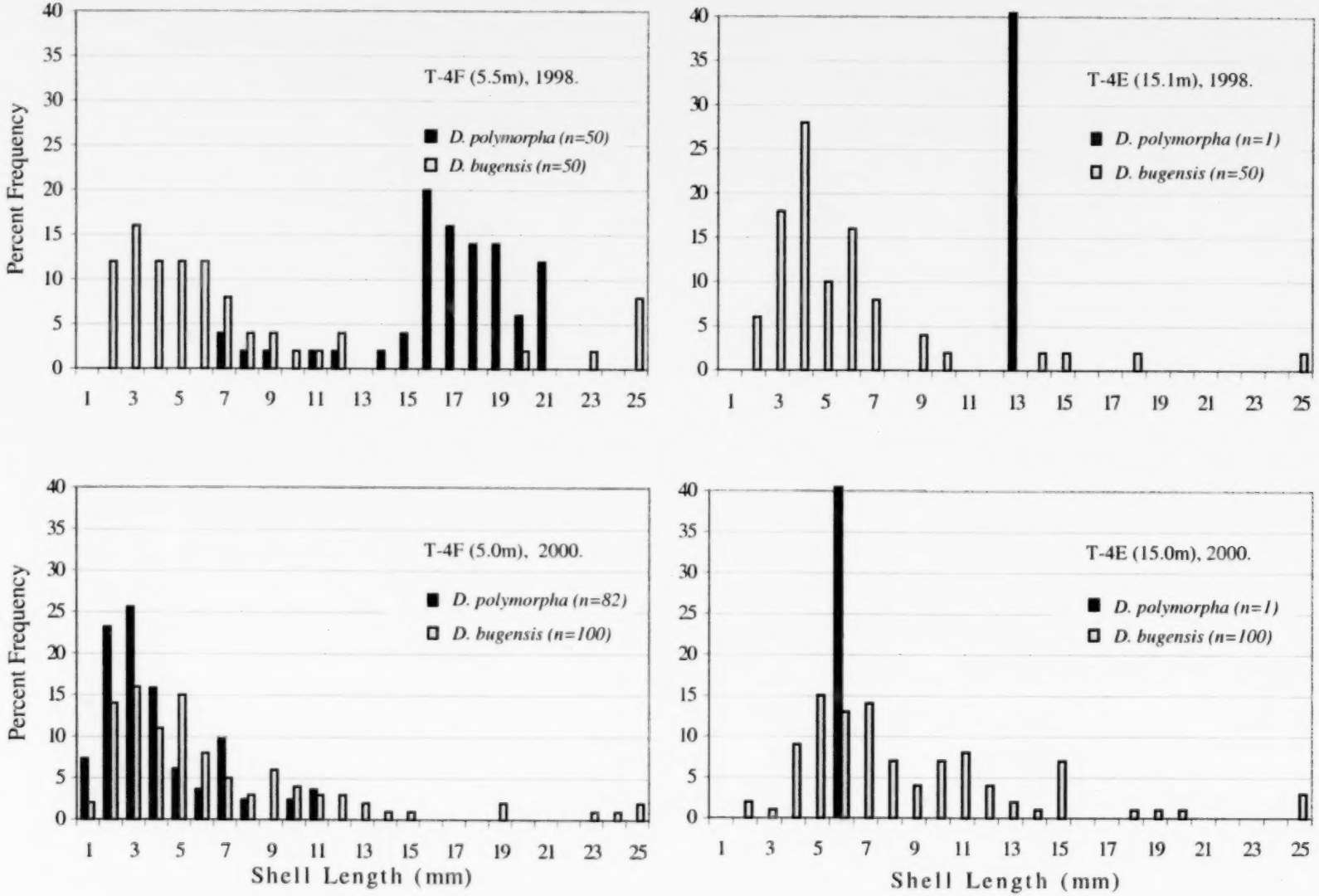

Figure 13. Comparison of *Dreissena* spp. size frequency at two sites on Transect 4 in the lower Bay of Quinte in 1998 and 2002.

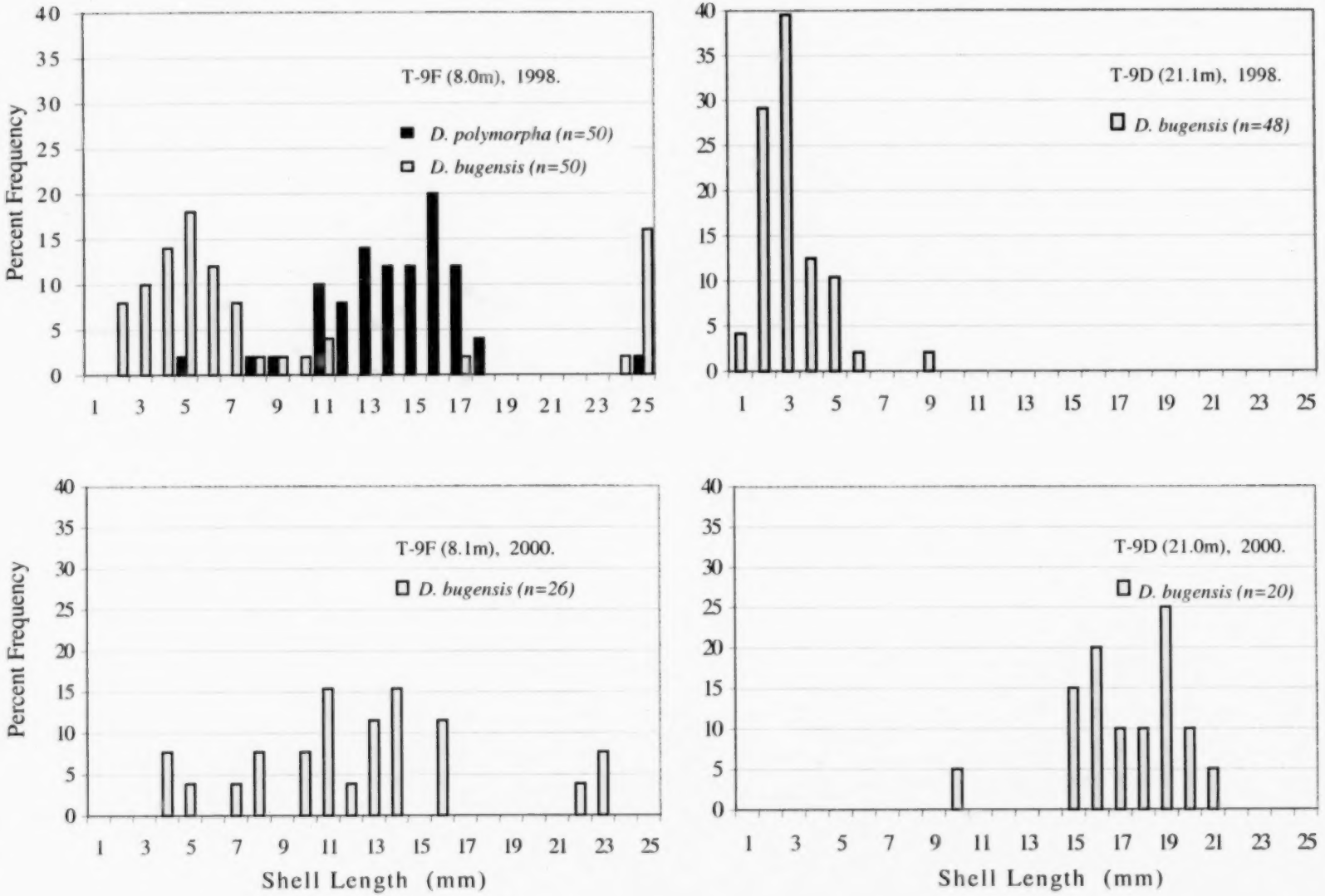

Figure 14. Comparison of *Dreissena* spp. size frequency at two sites on Transect 9 in the lower Bay of Quinte in 1998 and 2002.

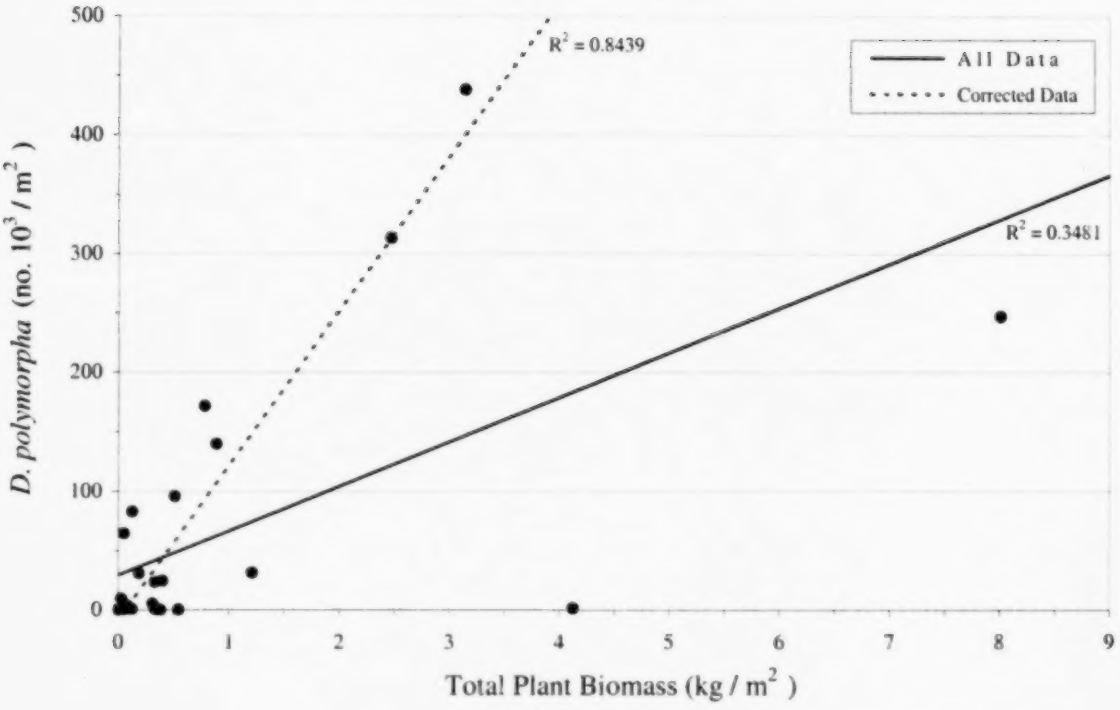

Figure 15. Regression between *Dreissena polymorpha* density (thousands/m^2) and total macrophyte biomass (kg wet weight/m^2) for the Upper Quinte 2000 Ponar survey. Dotted line is regression without the two right outliers which represent dense macrophytes. Only sites with macrophytes present were used.

Table 1. Bay of Quinte Ponar grab site identification and locations in 1998 and 2000.

Area Designation	Ponar Site	Depth (m)	Latitude	Longitude
Upper Bay				
Trenton	U1-01	1.5	44° 03.698'	77° 34.855'
	U1-02	2.5	44° 03.825	77° 34.718
	U1-03	3.2	44° 04.013	77° 34.521
	U1-05	2.0	44° 04.337	77° 34.145
	U1-05	3.6	44° 04.277	77° 34.201
	U2-01	2.0	44° 04.520	77° 34.153
	U2-01*	3.2	44° 04.580	77° 34.200
	U2-01	3.8	44° 04.587	77° 34.196
	U2-02	3.8	44° 04.674	77° 34.217
	U2-05	2.7	44° 05.040	77° 34.456
	U2-06	2.1	44° 05.123	77° 34.543
	U3-01	2.0	44° 05.992	77° 32.805
	U3-01	2.8	44° 05.961	77° 32.804
	U3-07**	3.5	44° 05.500	77° 32.409
	U4-01	1m Littoral	44° 04.800	77° 31.901
	U4-01**	2.0	44° 04.805	77° 31.910
	U4-01**	3.0	44° 04.814	77° 31.964
	U4-02*	2.0	44° 04.850	77° 31.980
	U4-03*	3.0	44° 04.909	77° 32.042
	U4-07*	3.2	44° 05.500'	77° 32.410'
Upper Bay				
Belleville	Belleville Buoy	4.8	44° 09.277'	77° 20.702'
	U9-01*	2.0	44° 09.650	77° 20.680
	U9-01	4.0	44° 09.693	77° 20.698
	U9-03	4.6	44° 09.183	77° 20.588
	U9-06	5.0	44° 08.962	77° 20.581
	U9-07	4.6	44° 08.783	77° 20.572
	U9-08	3.0	44° 08.719	77° 20.594
	U10-01	1m Littoral	44° 08.890	77° 18.666
	U10-01	2.0	44° 08.905	77° 18.667
	U10-01*	3.0	44° 08.800	77° 18.700
	U10-02	3.0	44° 08.916	77° 18.660
	U10-03	5.0	44° 08.944	77° 18.633
	U10-07	4.0	44° 09.201	77° 18.630
	U10-08**	2.0	44° 09.271	77° 18.593
	U10-08**	3.0	44° 09.268'	77° 18.606'
Upper Bay				
Big Bay	U14-01	1m Littoral	44° 07.642'	77° 15.619'
	U14-02	2.0	44° 07.660	77° 15.620
	U14-02	3.0	44° 07.681	77° 15.642
	U14-03	4.3	44° 07.708'	77° 15.651'

Continued on next page.

Table 1. Continued. Bay of Quinte Ponar grab site identification and locations in 1998 and 2000.

Area Designation	Ponar Site	Depth (m)	Latitude	Longitude
Middle Bay				
	Foresters Island	3.0	44° 10.665'	77° 03.970'
	Foresters Island	4.0	44° 10.657	77° 03.929
	Foresters Island**	8.5	44° 10.582	77° 04.267
	Hay Bay North	2.1	44° 06.268	77° 03.404
	Hay Bay North	4.0	44° 06.238	77° 03.380
	Hay Bay North	5.0	44° 06.233	77° 03.354
	Hay Bay West	2.0	44° 05.834	77° 04.785
	Hay Bay West	4.0	44° 05.828	77° 04.779
	Hay Bay West	12.4	44° 05.826	77° 04.755
	Hay Bay Buoy	11.1	44° 05.621	77° 04.250
	Napanee Buoy	4.8	44° 10.814	77° 02.381
	Napanee S.E.**	2.0	44° 10.952	77° 01.719
	Napanee S.E.	3.6	44° 11.002	77° 01.796
	Unger Point**	2.0	44° 11.703	77° 01.855
	Unger Point	3.0	44° 11.702	77° 01.855
	Unger Point	4.1	44° 11.654'	77° 01.833'
Lower Bay				
	T-4D	8.9	44° 03.011'	76° 58.448'
	T-4E	15.0	44° 03.597	76° 58.963
	T-4F	5.0	44° 03.665	76° 58.994
	T-7D	15.2	44° 05.138	76° 56.412
	T-7E	8.2	44° 05.096	76° 56.688
	T-7G	9.0	44° 04.376	76° 55.304
	T-9D	21.0	44° 06.403	76° 54.536
	T-9E	9.9	44° 06.454	76° 54.761
	T-9F	8.1	44° 05.545	76° 53.726
	T-11D	19.8	44° 07.330	76° 52.824
	T-11F	10.5	44° 06.423	76° 51.774
	T-11H	7.0	44° 07.372	76° 52.944
	T-13C	21.5	44° 08.321	76° 50.691
	T-13F	21.6	44° 07.487	76° 49.617
	T-13G	16.3	44° 07.382	76° 49.544
	Conway Buoy**	33.0	44° 06.457	76° 53.920
	Conway Dive 3m**	3.3	44° 06.123	76° 55.443
	Conway Dive 8m**	7.8	44° 06.100	76° 55.370
	Conway Dive 15m**	15.9	44° 06.023	76° 55.336
	Glenora Dive 8 m**	8.0	44° 02.618	77° 03.657
	Glenora Buoy	20.0	44° 02.790'	77° 01.222'

* Sites sampled in 1998 only. ** Sites sampled in 2000 only.

Table 2. Bay of Quinte Dive site identification and locations for 2000.

Area Designation	Dive Site	Depth (m)	Latitude	Longitude
Upper Bay				
Trenton	Indian Island	2.5	44° 04.4186'	77° 33.9696'
	Makatewis Shoal	3.0	44° 06.6584'	77° 29.6764'
Upper Bay				
Big Bay	Big Island	2.0	44° 07.3796'	77° 16.1427'
	Big Island	3.0	44° 07.3843	77° 16.1415
	Big Island	3.4	44° 07.8034	77° 16.6875
	Muscote Bay	2.0	44° 05.7069	77° 17.5457
	Trident Point	2.4	44° 09.2068'	77° 12.9940'
Middle Bay	Foresters Island	3.0	44° 10.7056'	77° 03.8567'
	Hogs Back	3.0	44° 07.8828'	77° 03.7944'
Lower Bay	Conway	3.0	44° 06.1063'	77° 55.4431'
	Conway	8.0	44° 06.0636	76° 55.4242
	Glenora	3.0	44° 02.5877	77° 03.7231
	Glenora	8.0	44° 02.6134	76° 03.6538
	Indian Point	3.0	44° 06.4855	76° 51.5707
	Indian Point	8.0	44° 06.5431'	76° 51.5439'

Table 3. Bay of Quinte 1998. Average *Dreissena* spp. density (no./m^2) and biomass (g/m^2 wet weight with shells) by depth (m) from Ponar samples collected in various parts of the Bay of Quinte, n = number of replicates, na = not available.

			Total *Dreissena*				**Zebra Mussels**				**Quagga Mussels**			
			Density		Biomass		Density		Biomass		Density		Biomass	
Station Depth	n =		Ave.	S.E.	Mean	S.E.	Ave.	S.E.	Mean	S.E.	Ave.	S.E.	Mean	S.E.
Trenton														
0 - 3	23		7549	2316	595.0	305.4	7537	2310	591.1	303.2	12	0.3	0.1	0.1
3.1-5	10		5	5	0.1	0.1	5	5	0.1	0.1	0	na	0.0	na
	33	Ave. =	5263	1717	414.7	216.9								
Belleville-Big Bay														
0 - 3	17		5860	1446	2113.1	678.6	5860	1446	2113.1	678.6	0	na	0.0	na
3.1-5	14		2022	1114	940.8	532.7	2022	1114	940.8	532.7	0	na	0.0	na
	31	Ave. =	4127	988	1583.7	449.0								
Middle Bay														
0 - 3	8		9461	3507	1644.4	655.0	8184	3265	1517.3	645.8	1277	811	127.1	70.4
3.1-5	14		6281	3068	1796.8	750.0	3449	1107	1380.6	504.5	2832	2364	416.2	326.3
5.1 - 10	7		13	8	0.1	0.1	0	na	0.0	na	13	8	0.1	0.1
	29	Ave. =	5645	1839	1321.1	419.1								
Lower Bay														
<5 m	0		Nil samples											
5.1-10	6		41080	10406	5498.2	1188.8	4030	1527	1805.2	520.2	37050	9455	3693.0	743.3
10.1-15	2		58890	14550	5932.7	751.6	4160	440	1308.9	193.0	54730	14990	4623.7	944.5
15.1-20	3		14307	7389	4364.3	2488.5	1833	917	876.9	700.9	12473	6679	3487.5	1847.3
20+	10		1504	1010	280.4	216.9	96	81	108.1	98.1	1408	932	172.4	119.3
	21	Ave. =	20106	5628	2893.0	721.9								

Table 4. Bay of Quinte 2000. Average *Dreissena* spp. density (no./m^2) and biomass (g/m^2 wet weight with shells) by depth (m) from combined dive and Ponar survey data, n = number of replicates, na = not available.

			Total *Dreissena*				Zebra Mussels				Quagga Mussels			
			Density		Biomass		Density		Biomass		Density		Biomass	
Station Depth	n =		Ave.	S.E.	Mean	S.E.	Ave.	S.E.	Mean	S.E.	Ave.	S.E.	Mean	S.E.
Trenton														
0 - 3	31		41874	13655	2223.8	778.9	41859	13655	2205.2	770.9	14	8	18.5	9.7
3.1-5	10		149	71	0.7	0.3	149	71	0.7	0.3	0	na	0	na
	41	Ave. =	31697	10666	1681.6	605.6								
Belleville-Big Bay														
0 - 3	36		51119	12578	3232.9	504.2	51078	12576	3210.9	499.9	41	28	22.0	12.5
3.1-5	19		31115	14753	3809.3	1647.5	31082	14737	3784.0	1633.9	34	19	25.3	16.0
	55	Ave. =	44209	9688	3432.0	649.5								
Middle Bay														
0 - 3	21		45287	15279	3639.3	724.9	44465	15320	2979.1	608.7	822	317	660.2	253.2
3.1-5	12		27851	24890	2557.8	1014.8	24000	22070	782.4	280.1	3851	2865	1775.4	829.9
5.1 - 10	6		30	22	0.1	0.1	30	22	0.1	0.1	0	na	0	na
	39	Ave. =	32960	11318	2746.6	531.8								
Lower Bay														
<5 m	19		39085	10169	4110.9	860.9	18733	7186	437.7	141.8	20352	4269	3673.2	752.6
5.1-10	31		30031	3299	7269.1	731.2	331	149	34.9	15.6	29701	3332	7234.2	728.0
10.1-15	4		18158	4387	3753.1	950.1	34	11	0.8	0.4	18124	4383	3752.3	949.7
15.1-20	10		9828	3908	2153.2	785.3	81	33	29.4	15.4	9747	3913	2123.8	787.5
20+	8		1361	618	663.8	354.3	39	33	51.0	40.6	1322	586	612.9	314.2
	72	Ave. =	25769	3385	4795.9	491.2								

Table 5. Bay of Quinte 2000 Ponar survey only. Average *Dreissena* spp. density (no./m^2) and biomass (g/m^2 wet weight with shell) by depth (m) using only data from Ponar samples collected in 2000, n = number of replicates, na = not available.

			Total *Dreissena*				Zebra Mussels				Quagga Mussels			
			Density		Biomass		Density		Biomass		Density		Biomass	
Station Depth	n =		Ave.	S.E.	Mean	S.E.	Ave.	S.E.	Mean	S.E.	Ave.	S.E.	Mean	S.E.
Trenton														
0 - 3	21		51638	19723	923.1	403.5	51638	19723	923.1	403.5	0	na	0.0	na
3.1-5	10		149	71	0.7	0.3	149	71	0.7	0.3	0	na	0.0	na
	31	Ave. =	35028	13963	625.5	282.4	35028	13963	625.5	282.4	0	na	0.0	na
Belleville-Big Bay														
0 - 3	16		67366	25525	3763.9	597.7	73244	25178	3628.3	592.7	93	60	49.5	27.0
3.1-5	14		2414	1773	419.2	275.2	2414	1773	419.2	275.2	0	na	0.0	na
	30	Ave. =	37055	14717	2203.1	458.7	40190	14785	2130.7	448.5	50	33	26.4	14.9
Middle Bay														
0 - 3	11		58909	28157	2418.8	788.7	57760	28282	1613.4	510.2	1150	575	805.3	435.1
3.1-4.9	12		27851	24890	2557.8	1014.8	24000	22070	782.4	280.1	3851	2865	1775.4	829.9
5.1 - 10	6		30	22	0.1	0.1	30	22	0.0	na	0	na	0.0	na
	29	Ave. =	33876	15020	1975.9	536.8	31846	14319	935.8	247.1	2030	1212	1040.1	392.8
Lower Bay														
<5 m	4		16515	5504	1439.9	779.9	5659	3155	57.4	19.7	10856	4792	1382.5	771.1
5.1-10	16		22888	3237	4943.1	718.3	28	17	2.1	1.5	22860	3236	4941.0	718.7
10.1-15	4		18158	4387	3753.1	950.1	34	11	0.8	0.4	18124	4383	3752.3	949.7
15.1-20	10		9828	3908	2153.2	785.3	81	33	29.4	15.4	9747	3913	2123.8	787.5
20+	8		1361	618	663.8	354.3	39	33	51.0	40.6	1322	586	612.9	314.2
	42	Ave. =	14621	2059	3016.7	436.2	580	368	23.0	9.0	14041	2051	2993.7	437.5

Table 6a. Statistical comparison of *Dreissena* spp. densities and biomass ($\log_n$ transformed) of the 1998 and 2000 Bay of Quinte Ponar surveys.

Variable	*df*	Mean-Square	*F*	*p*
Density				
Year	1	75.555	4.312	0.039*
Site	5	49.603	2.831	0.017*
Year-Site	5	7.058	0.403	0.847
1998 Sites	5	38.312	2.294	0.050
2000 Sites	5	14.751	0.807	0.547
Biomass				
Year	5	77.863	6.686	0.000**
Site	1	47.336	4.064	0.045
Year-Site	5	0.571	0.049	0.999
1998 Sites	5	34.875	2.894	0.017
2000 Sites	5	86.975	7.517	0.000**

* significant difference in *Dreissena* spp. densities between individual sites $p < 0.05$
** significant difference in biomass $p < 0.01$

Table 6b. Statistical matrix of pairwise site comparison of the biomass ($\log_n$ transformed) for the 1998 and 2000 Ponar surveys in the Bay of Quinte.

Comparison Set	*p* value	
	1998	2000
Conway : Trenton	0.030*	0.000***
Conway : Belleville - Big Bay	1.000	0.046*
Conway : Napanee	0.358	0.011*
Glenora : Napanee	1.000	0.043*
Glenora : Trenton	0.222	0.000***
Trenton: Belleville - Big Bay	1.000	0.175
Trenton: Hay Bay	1.000	0.117

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7. Statistical comparison of *Dreissena* spp. density and biomass in dive and Ponar samples at the same sites during 2000 using Student's *t*-test. Negative *t* values indicate higher averages in the Ponar samples.

Site	Depth (m)	Density *t* value	Biomass *t* value	*df*
Foresters Island	3.0	-0.912	0.339	6
Glenora	8.0	0.072	0.306	6
Conway	3.0	-0.775	2.677*	6
Conway	8.0	1.820	3.092**	6

* $p < 0.05$, ** $p < 0.01$

Table 8. Percent quagga mussels in the total *Dreissena* density in the 1998 and 2000 samples (dive and Ponar) from the Bay of Quinte.

Site	Depth (m)	% Quagga 1998	% Quagga 2000
Upper Bay	0 - 5	0.1	0.1
Middle Bay	0 - 3	13.5	1.8
	3.1 - 5	45.1	13.8
	5.1 - 10	100.0	0.0
Lower Bay	<5 m	Nil samples	52.1
	5.1 - 10	90.2	98.9
	10.1-15	92.9	99.8
	15.1-20	87.2	99.2
	20+	93.6	97.1

Table 9. Average density (all size ranges, no./m^2), percentage of mussels < 5 mm in length and average individual wet biomass (mg/individual with shells) in the Bay of Quinte from data in the 2000 dive and Ponar samples, n = number of replicates.

			Total *Dreissena*			Zebra Mussels				Quagga Mussels			
Station Depth (m)	n =		Density Ave.	% *< 5mm*	Individual Biomass	Density Ave.	Density < 5mm	% *< 5mm*	Individual Biomass	Density Ave.	Density < 5mm	% *< 5mm*	Individual Biomass
Trenton													
0 - 3	31		41874	*79.2*	53.1	41859	33165	*79.2*	52.7	14	0	*0*	1321.4
3.1-5	10		149	*93.6*	4.7	149	140	*93.6*	4.7	0	0	*0*	-
	41	Ave. =	31697	*86.4*	53.1								
Belleville-Big Bay													
0 - 3	36		51120	*65.2*	63.2	51078	33337	*65.3*	62.9	41	10	*24.2*	533.7
3.1-5	19		31115	*68.0*	122.4	31082	21156	*68.1*	121.7	34	0.0	*0*	750.1
	55	Ave. =	44209	*66.6*	77.6								
Middle Bay													
0 - 3	21		45288	*74.5*	80.4	44465	33624	*75.6*	67.0	823	93	*11.3*	803.0
3.1-4.9	12		27851	*84.2*	91.8	24000	21296	*88.7*	32.6	3851	2145	*55.7*	461.0
5.1 - 10	6		30	*100.0*	2.7	30	30	*100.0*	2.7	0	0.0	*0*	-
	39	Ave. =	32960	*86.2*	83.3								
Lower Bay													
<5 m	19		39085	*53.3*	105.2	18733	15804	*84.4*	23.4	20352	5015	*24.6*	180.5
5.1-10	31		30031	*19.3*	242.0	331	102	*30.7*	105.5	29701	5689	*19.2*	243.6
10.1-15	4		18158	*11.5*	206.7	34	11	*33.1*	23.1	18124	2070	*11.4*	207.0
15.1-20	10		9828	*24.0*	219.1	81	0	*0.0*	362.9	9747	2363	*24.2*	217.9
20+	8		1361	*3.7*	487.7	39	0	*0.0*		1322	51	*3.8*	463.6
	72	Ave. =	25769	*22.4*	186.1								

Table 10a. *Dreissena* density (no./m^2) at littoral sites in depths less than 2 metres at Amherst Island (lower bay), Big Bay and Trenton (upper Bay of Quinte), na = not available.

Survey	Amherst Island		Big Bay (Big Bay Island)		Trenton (Oderdonk Point)	
	Density	S.E.	Density	S.E.	Density	S.E.
October 1992	0	0	0	0	0	0
October 1993	879	293	0	0	0	0
July 1994	2400	1192	154	40	na	na
June 1995	1661	542	6241	2053	3518	1104
July 1995 (<2m)	409	225	3817	865	na	na
July 1995 (>2m)	1080	330	na	na	na	na
October 1995	2764	546	17221	2254	na	na
May 1996	318	115	221	64	13665	2661
August 1996	1182	451	2532	1046	15233	2736
August 1997	na	na	2612	486	na	na
August 1998	na	na	5903	957	na	na
October 1998	na	na	16370	1163	23730	2237
August 1999	na	na	232	46	na	na
October 2000	na	na	35225	4963	49482	3967

Table 10b. *Dreissena* density (no./m^2) and biomass (g/m^2 wet weight with shells) of *Dreissena* at sites T-9D and T-13F (Lower Bay of Quinte), na = not available.

Survey	Site T-9D (Conway) 21 – 21.5m		Site T-13F (Upper Gap) 20 – 21m	
	Density	Biomass	Density	Biomass
July 1994	20	1.30	130	5.72
July 1995	20	0.86	120	89.76
August 1998	960	4.26	2380	230.28
October 2000	675	372.84	3015	1684.96

Table 11. Hypsographic areas for Trenton and the Belleville-Big Bay sections of the Upper Bay of Quinte.

Depth Zone (m)	Trenton (10^6 m^2)	Belleville & Big Bay (10^6 m^2)	Zone Total (10^6 m^2)
0 - 1	4.7418	11.5676	16.3095
1 - 2	6.0450	10.1301	16.1751
2 - 3	10.4336	9.3366	19.7701
3 - 4	10.8598	10.4594	21.3192
4 - 5	5.2288	21.3887	26.6175
5 - 6	0.0444	9.5021	9.5465
6 - 7	0	0.3075	0.3075
7 - 8		0.1049	0.1049
8 - 9		0.0765	0.0765
9 - 10		0.0455	0.0455
10 - 11		0.0018	0.0018
11 - 12		0	0
Zone Totals =	37.3535	72.9208	110.2742

Table 12. Area weighted biomass (kg/m^2 wet weight with shells) from Ponar and dive samples based on area of depth contours for the Trenton and Belleville-Big Bay sections of the upper Bay of Quinte for October 1998 and October 2000, na = not available.

Upper Bay of Quinte			1998				2000			
Depth Zone (m)	Bottom Area (m^2)	Total Area %	*Dreissena* spp. Biomass	S.E.	Total for Section Biomass	S.E.	*Dreissena* spp. Biomass	S.E.	Total for Section Biomass	S.E.
Trenton										
0 – 3	21.22×10^6	56.8	0.5950	0.3054	12.63×10^6	6.481×10^6	2.2238	0.7789	47.19×10^6	16.53×10^6
3 – 5	16.09×10^6	43.1	0.0*	0.0*	0.002×10^6	0.002×10^6	0.0*	0.0*	0.011×10^6	0.005×10^6
>5	0.044×10^6	0.1	na	na	na	na	na	na	na	na
Total Area =	37.35×10^6	100.0			12.63×10^6	6.483×10^6			47.20×10^6	16.54×10^6
			0.3381 kg/m^2 = Area weighted Average				*1.2637 kg/m^2 = Area weighted Average*			
Belleville - Big Bay										
0 – 3	31.03×10^6	42.5	2.1131	0.6786	65.58×10^6	21.06×10^6	3.2329	0.5042	100.3×10^6	15.65×10^6
3 – 5	31.85×10^6	43.7	0.9408	0.5327	29.96×10^6	16.97×10^6	3.8093	1.6475	121.3×10^6	52.47×10^6
>5**	10.04×10^6	13.8	0.000002	0	0.00001	0	0.000305	0.000125	3.06×10^6	1.25×10^6
Total Area =	72.92×10^6	100.0			95.54×10^6	38.03×10^6			221.6×10^6	68.12×10^6
			1.3102 kg/m^2 = Area weighted Average				*3.0396 kg/m^2 = Area weighted Average*			
Upper Bay Combined										
Total Area = $110.27 \times 10^6 m^2$			Total Biomass = 108.17×10^6				Total Biomass = 268.85×10^6			
			0.9810 x kg/m^2 = Area weighted Average				*2.438 kg/m^2 = Area weighted Average*			

* > 1 gram reported

** values beyond 5 m from Big Bay Index sites 1998 and 2000, n=27

Table 13. *Hexagenia* density (no./m^2) and biomass (g/m^2 wet weight) in the Bay of Quinte for 1998 and 2000.

Site	Year	Depth (m)	Sample Device	*Hexagenia* Density	*Hexagenia* Biomass
Unger Point	1998	3.0	mini Ponar	45	2.106
Hay Bay	1998	5.0	mini Ponar	45	10.305
T-4D	1998	8.9	9" Ekman	100	2.814
T-4E	1998	15.1	9" Ekman	240	3.176
T-11F	1998	10.6	9" Ekman	100	1.524
T-4E	2000	15.0	mini Ponar	90	12.780

Appendix 1a. Upper Bay of Quinte 1998 Ponar survey. *Dreissena* spp. density (no./m^2) and biomass (g/m^2 wet weight with shells) for mussels retained on 1 mm mesh and macrophyte biomass (g/m^2 wet weight). Depth =(m), D = dive, na = not available.

Trenton			Total *Dreissena*		Zebra Mussels		Quagga Mussels		Plants
Station	Depth	Sample	Density	Biomass	Density	Biomass	Density	Biomass	Biomass
U1-01	1.9	1	0	0.00	0	0.00	0	0.00	0.00
U1-01	1.9	2	90	9.46	90	9.46	0	0.00	1.87
U1-05	2	1	37665	4495.95	37395	4406.63	270	89.33	1.58
U1-05	2	2	25380	964.94	25380	964.94	0	0.00	5.92
U2-01	2	1	24660	713.16	24660	713.16	0	0.00	48.32
U2-01	2	2	13590	444.39	13590	444.39	0	0.00	60.40
U2-06	2	1	4275	335.12	4275	335.12	0	0.00	86.12
U2-06	2	2	13095	480.28	13095	480.28	0	0.00	84.20
U3-01	2	1	315	5.86	315	5.86	0	0.00	19.62
U3-01	2	2	4905	109.81	4905	109.81	0	0.00	7.54
U4-02	2	1	45	1.25	45	1.25	0	0.00	9.64
U4-02	2	2	0	0.00	0	0.00	0	0.00	0.00
U1-02	2.1	1	45	1.22	45	1.22	0	0.00	9.85
U1-02	2.1	2	0	0.00	0	0.00	0	0.00	0.00
U2-05	2.7	1	180	4.09	180	4.09	0	0.00	8.06
U2-05	2.7	2	225	4.83	225	4.83	0	0.00	5.60
U3-01	2.8	1	6795	130.46	6795	130.46	0	0.00	8.50
U3-01	2.8	2	18630	233.33	18630	233.33	0	0.00	66.31
U2-01	3	1	0	0.00	0	0.00	0	0.00	na
U2-01	3	2	0	0.00	0	0.00	0	0.00	0.00
U4-01*	1	1	23729	5751.00	23729	5751.00	0	0.00	na
U4-03	3	1	0	0.00	0	0.00	0	0.00	2.30
U4-03	3	2	0	0.00	0	0.00	0	0.00	0.00
U1-03	3.2	1	45	0.28	45	0.28	0	0.00	2.77
U1-03	3.2	2	0	0.00	0	0.00	0	0.00	2.45
U2-01	3.2	1	0	0.00	0	0.00	0	0.00	na
U2-01	3.2	2	0	0.00	0	0.00	0	0.00	na
U2-02	3.2	1	0	0.00	0	0.00	0	0.00	na
U2-02	3.2	2	0	0.00	0	0.00	0	0.00	na
U4-07	3.2	1	0	0.00	0	0.00	0	0.00	0.00
U4-07	3.2	2	0	0.00	0	0.00	0	0.00	0.00
U1-05	3.6	1	45	0.09	45	0.09	0	0.00	0.00
U1-05	3.6	2	0	0.00	0	0.00	0	0.00	0.00
n=	33	Ave.	5264	414.71	5255	412.00	8	2.71	15.39
		S.E.	1717	216.89	1712	215.31	8	2.71	5.03

* Oderdonk Point littoral site, data from quadrates (1/300 m^2).

Continued on next page.

Appendix 1a. Continued. Upper Bay of Quinte 1998 Ponar survey.

Belleville			**Total *Dreissena***		**Zebra Mussels**		**Quagga Mussels**		**Plants**
Station	Depth	Sample	Density	Biomass	Density	Biomass	Density	Biomass	Biomass
Belleville Buoy	4.1	1	0	0.00	0	0.00	0	0.00	na
Belleville Buoy	4.1	2	0	0.00	0	0.00	0	0.00	na
Belleville Buoy	4.1	3	0	0.00	0	0.00	0	0.00	na
U9-01	2	1	2205	282.20	2205	282.20	0	0.00	na
U9-01	2	2	5490	526.05	5490	526.05	0	0.00	na
U9-01	4	1	6345	2369.58	6345	2369.58	0	0.00	na
U9-01	4	2	0	0.00	0	0.00	0	0.00	na
U9-03	4.7	1	0	0.00	0	0.00	0	0.00	na
U9-03	4.7	2	0	0.00	0	0.00	0	0.00	na
U9-06	4	1	0	0.00	0	0.00	0	0.00	na
U9-06	4	2	0	0.00	0	0.00	0	0.00	na
U9-07	3	1	8100	3809.05	8100	3809.05	0	0.00	na
U9-07	3	2	15975	6557.15	15975	6557.15	0	0.00	na
U9-08	2	1	17280	1562.17	17280	1562.17	0	0.00	na
U9-08	2	2	4635	517.66	4635	517.66	0	0.00	na
U10-01*	1	1	6159	4113.59	6159	4113.59	0	0.00	na
U10-01	2	1	1755	63.68	1755	63.68	0	0.00	na
U10-01	2	2	135	2.29	135	2.29	0	0.00	na
U10-01	3	1	0	0.00	0	0.00	0	0.00	na
U10-01	3	2	90	3.64	90	3.64	0	0.00	na
U10-02	3	2	0	0.00	0	0.00	0	0.00	na
U10-03	4.5	1	0	0.00	0	0.00	0	0.00	na
U10-03	4.5	2	0	0.00	0	0.00	0	0.00	na
U10-07	4	1	0	0.00	0	0.00	0	0.00	na
n=	24	**Ave.**	2840	825.29	2840	825.29	0.00	0.00	na
		S.E.	1010	347.78	1010	347.78	0.00	0.00	na
Big Bay									
Station	Depth	Sample							
U14-02	2	1	540	84.41	540	84.41	0	0.00	na
U14-02	2	2	4545	366.84	4545	366.84	0	0.00	na
U14-03	3	1	10710	6618.94	10710	6618.94	0	0.00	na
U14-03	3	2	5625	3008.53	5625	3008.53	0	0.00	na
U14-01**	1	1	16370	8407.29	16370	8407.29	0	0.00	na
U14-03	4	1	10080	5611.97	10080	5611.97	0	0.00	na
U14-03	4	2	11880	5189.25	11880	5189.25	0	0.00	na
n=	7	**Ave.**	8536	4183.89	8536	4183.89	0	0.00	na
		S.E.	2000	1190.98	2000	1190.98	0	0.00	na

* Massassauga Point littoral site, data from quadrates (1/300 m^2).
** Big Bay littoral site, data from quadrates (1/300 m^2).

Appendix 1b. Middle Bay of Quinte 1998 Ponar survey. *Dreissena* spp. density (no./m^2) and biomass (g/m^2 wet weight with shells) for mussels retained on 1 mm mesh and macrophyte biomass (g/m^2 wet weight). Depth = (m), D = dive, na = not available.

Napanee			**Total *Dreissena***		**Zebra Mussels**		**Quagga Mussels**		**Plants**
Station	Depth	Sample	Density	Biomass	Density	Biomass	Density	Biomass	Biomass
Foresters Island	3	1	1755	458.26	1755	458.26	0	0.00	na
Foresters Island	3	2	8955	3732.66	8955	3732.66	0	0.00	na
Unger Point	3	1	270	11.38	270	11.38	0	0.00	na
Unger Point	3	2	0	0.00	0	0.00	0	0.00	na
Napanee Buoy	4.8	1	90	0.24	90	0.24	0	0.00	na
Napanee Buoy	4.8	2	45	0.05	45	0.05	0	0.00	na
Napanee S.E.	4	1	45	0.03	45	0.03	0	0.00	na
Napanee S.E.	4	2	0	0.00	0	0.00	0	0.00	na
Foresters Island	4	1	0	0.00	0	0.00	0	0.00	na
Foresters Island	4	2	2790	268.22	2790	268.22	0	0.00	na
Foresters Island	4	1	8370	2853.24	8370	2853.24	0	0.00	na
Foresters Island	4	2	6930	2841.82	6930	2841.82	0	0.00	na
Unger Point	4	1	45	1.33	45	1.33	0	0.00	na
Unger Point	4	2	45	0.21	45	0.21	0	0.00	na
n=	14	**Ave.**	2096	726.25	2096	726.25	0	0.00	na
		S.E.	901	355.86	901	355.86	0	0.00	na
Hay Bay									
Station	Depth	Sample							
Hay Bay North	4	1	43785	10025.21	10665	5491.50	33120	4533.71	na
Hay Bay North	4	2	7875	1781.81	2250	679.05	5625	1102.76	na
Hay Bay North	5	1	0	0.00	0	0.00	0	0.00	na
Hay Bay North	5	2	0	0.00	0	0.00	0	0.00	na
Hay Bay North	2	1	5895	359.90	4050	280.42	1845	79.48	na
Hay Bay North	2	2	16470	1647.50	9765	1068.98	6705	578.52	na
Hay Bay West	2	1	13455	4981.80	12915	4828.79	540	153.01	na
Hay Bay West	2	2	28890	1963.63	27765	1757.81	1125	205.82	na
Hay Bay West	4	1	8910	4107.83	8145	3944.32	765	163.51	na
Hay Bay West	4	2	9000	3275.46	8865	3248.31	135	27.15	na
Hay Bay West	10	1	0	0.00	0	0.00	0	0.00	na
Hay Bay West	10	2	0	0.00	0	0.00	0	0.00	na
Hay Bay Buoy	9	1	45	0.04	0	0.00	45	0.04	na
Hay Bay Buoy	9	2	45	0.14	0	0.00	45	0.14	na
Hay Bay Buoy	9	3	0	0.00	0	0.00	0	0.00	na
n=	15	**Ave.**	8958	1876.22	5628	1419.95	3330	456.28	na
		S.E.	3279	723.74	1998	507.62	2196	301.44	na

Appendix 1c. Lower Bay of Quinte 1998 Ponar survey. *Dreissena* spp. density (no./m^2) and biomass (g/m^2 wet weight with shells) for mussels retained on 1 mm mesh and macrophyte biomass (g/m^2 wet weight). Depth =(m), D = dive, na = not available.

Glenora			**Total *Dreissena***		**Zebra Mussels**		**Quagga Mussels**		**Plants**
Station	Depth	Sample	Density	Biomass	Density	Biomass	Density	Biomass	Biomass
Glenora Buoy	20.1	1	90	4.94	90	4.94	0	0.00	na
Glenora Buoy	20.1	2	0	0.00	0	0.00	0	0.00	na
Glenora Buoy	20.1	3	0	0.00	0	0.00	0	0.00	na
T-4D	8.9	1	36880	4569.36	2760	1403.95	34120	3165.41	na
T-4E	15.1	1	3960	110.50	20	5.93	3940	104.57	na
T-4F	5.5	1	30680	1958.21	1380	895.25	29300	1062.96	na
T-7D	15.0	1	10340	8728.78	2500	2263.52	7840	6465.26	na
T-7E	7.8	1	58080	5284.73	1560	1550.24	56520	3734.49	na
T-7G	9.4	1	28540	7463.58	6040	1812.93	22500	5650.65	na
T-9D	21.1	1	960	4.26	0	0.00	960	4.26	na
T-9E	10.0	1	73440	5181.11	3720	1501.90	69720	3679.21	na
T-9F	8.0	1	82380	10127.79	10780	4294.52	71600	5833.37	na
n=	12	**Ave.**	27113	3619.44	2404	1144.43	24708	2475.01	na
		S.E.	8692	1089.77	935	375.06	8007	743.11	na

Conway									
Station	Depth	Sample	Density	Biomass	Density	Biomass	Density	Biomass	Biomass
Conway Buoy	33.0	1	140	38.00	0	0.00	140	38.00	na
Conway Buoy	33.0	2	140	148.00	0	0.00	140	148.00	na
Conway Buoy	33.0	3	140	56.00	0	0.00	140	56.00	na
T-11D	20.0	1	800	23.42	0	0.00	800	23.42	na
T-11F	10.6	1	44340	6684.24	4600	1115.98	39740	5568.27	na
T-11H	7.0	1	9920	3585.52	1660	874.33	8260	2711.19	na
T-13C	21.0	1	10340	2211.57	820	987.92	9520	1223.65	na
T-13F	21.6	1+2	2430	318.30	50	88.02	2380	230.28	na
T-13G	15.1	1	28620	4253.68	2980	361.14	25640	3892.54	na
n=	9	**Ave.**	10763	1924.30	1123	380.82	9640	1543.48	na
		S.E.	5210	810.71	554	158.94	4663	683.58	na

Appendix 2a. Upper Bay of Quinte 2000. *Dreissena* spp. density (no./m^2) and biomass (g/m^2 wet weight with shells) for mussels retained on 1 mm mesh and macrophyte biomass (g/m^2 wet weight). All data from the Ponar and dive samples are included, depth =(m), D = dive, na = not available.

Trenton			Total *Dreissena*		Zebra Mussels		Quagga Mussels		Plants
Station	Depth	Sample	Density	Biomass	Density	Biomass	Density	Biomass	Biomass
Indian Island	2.5	D-1	10450	661.30	10450	661.30	0	0.00	na
Indian Island	2.5	D-2	0	0.00	0	0.00	0	0.00	na
Indian Island	2.5	D-5	12540	755.80	12540	755.80	0	0.00	na
Indian Island	2.5	D-9	49438	3118.13	49438	3118.13	0	0.00	na
Indian Island	2.5	D10	7180	59.20	7180	59.20	0	0.00	na
Makatewis Shoal	3.0	D-1	14960	5740.05	14790	5553.05	170	187.00	na
Makatewis Shoal	3.0	D-2	60945	19147.10	60775	18929.50	170	217.60	na
Makatewis Shoal	3.0	D-5	10570	2635.26	10548	2583.18	22	52.08	na
Makatewis Shoal	3.0	D-9	8760	3152.00	8760	3152.00	0	0.00	na
Makatewis Shoal	3.0	D10	38845	14284.25	38760	14166.10	85	118.15	na
U1-01	1.5	1	247140	2315.25	247140	2315.25	0	0.00	8012.3
U1-01	1.5	2	720	3.67	720	3.67	0	0.00	125.6
U1-02	2.5	1	3735	63.32	3735	63.32	0	0.00	80.2
U1-02	2.5	2	24570	153.95	24570	153.95	0	0.00	403.6
U1-03	3.2	1	45	0.36	45	0.36	0	0.00	10.9
U1-03	3.2	2	0	0.00	0	0.00	0	0.00	0.0
U1-05	2	2	83070	2641.46	83070	2641.46	0	0.00	127.3
U1-05	2	1	139905	2394.63	139905	2394.63	0	0.00	888.5
U1-05	3.6	1	0	0.00	0	0.00	0	0.00	0.0
U1-05	3.6	2	45	0.09	45	0.09	0	0.00	0.0
U2-01	2	1	31680	298.89	31680	298.89	0	0.00	1212.9
U2-01	2	2	171675	1003.10	171675	1003.10	0	0.00	780.3
U2-01	3.8	1	0	0.00	0	0.00	0	0.00	0.0
U2-01	3.8	2	270	2.93	270	2.93	0	0.00	0.0
U2-02	3.8	1	45	0.41	45	0.41	0	0.00	0.0
U2-02	3.8	2	630	1.89	630	1.89	0	0.00	21.7
U2-05	2.7	1	675	13.32	675	13.32	0	0.00	334.7
U2-05	2.7	2	720	13.98	720	13.98	0	0.00	104.0
U2-06	2.1	1	180	38.43	180	38.43	0	0.00	545.7
U2-06	2.1	2	1485	359.27	1485	359.27	0	0.00	4125.0
U3-01	2	1	495	138.83	495	138.83	0	0.00	364.1
U3-01	2	2	0	0.00	0	0.00	0	0.00	382.3
U3-01	2.8	1	0	0.00	0	0.00	0	0.00	41.0
U3-01	2.8	2	0	0.00	0	0.00	0	0.00	0.0
U3-07	3.5	1	0	0.00	0	0.00	0	0.00	0.0
U3-07	3.5	2	450	1.31	450	1.31	0	0.00	46.4
U4-01*	1	1	49482	7968.67	49482	7968.67	0	0.00	na
U4-01	2	1	5400	85.23	5400	85.23	0	0.00	312.1
U4-01	2	2	313290	1850.81	313290	1850.81	0	0.00	2470.4
U4-01	3	1	9360	37.62	9360	37.62	0	0.00	28.7
U4-01	3	2	810	3.66	810	3.66	0	0.00	0.0
n=	41	**Ave.**	31697	1681.56	31686	1667.54	11	14.02	658.6
		S.E.	10666	605.64	10666	599.52	6	7.45	289.1

* Oderdonk Point littoral site, data from quadrates (1/300m^2).

Continued on next page.

Appendix 2a. Continued. Upper Bay of Quinte 2000.

Belleville			**Total *Dreissena***		**Zebra Mussels**		**Quagga Mussels**		**Plants**
Station	Depth	Sample	Density	Biomass	Density	Biomass	Density	Biomass	Biomass
Belleville Buoy	4.8	1	0	0.00	0	0.00	0	0.00	0.0
Belleville Buoy	4.8	2	0	0.00	0	0.00	0	0.00	0.0
U9-01	4	1	450	172.62	450	172.62	0	0.00	0.0
U9-01	4	2	8955	2748.14	8955	2748.14	0	0.00	0.0
U9-03	4.6	1	0	0.00	0	0.00	0	0.00	0.0
U9-03	4.6	2	90	0.54	90	0.54	0	0.00	0.0
U9-06	5	1	0	0.00	0	0.00	0	0.00	0.0
U9-07	4.6	1	0	0.00	0	0.00	0	0.00	0.0
U9-08	3	1	66195	5543.46	65880	5320.17	315	223.29	0.0
U9-08	3	2	73440	7903.44	72495	7513.56	945	389.88	0.0
U10-01*	1	1	48939	4241.71	48939	4241.71	0	0.00	na
U10-01	2	1	50760	5872.28	50625	5780.34	135	91.94	0.0
U10-01	2	2	47070	3667.86	47070	3667.86	0	0.00	0.0
U10-02	3	1	66690	6420.56	66645	6376.82	45	43.74	0.0
U10-02	3	2	61065	4836.56	61020	4792.82	45	43.74	0.0
U10-03	5	1	0	0.00	0	0.00	0	0.00	0.0
U10-03	5	2	0	0.00	0	0.00	0	0.00	0.0
U10-07	4	1	225	1.35	225	1.35	0	0.00	0.0
U10-07	4	2	0	0.00	0	0.00	0	0.00	0.0
U10-08	2	1	438030	3728.39	438030	3728.39	0	0.00	3140.1
U10-08	2	2	30780	1381.14	30780	1381.14	0	0.00	187.9
U10-08	3	1	0	0.00	0	0.00	0	0.00	0.0
U10-08	3	2	0	0.00	0	0.00	0	0.00	0.0
n=	23	**Ave.**	38813	2022.52	38748	1988.06	65	34.46	144.7
		S.E.	19038	549.97	19033	536.67	43	19.22	136.4

* Massassauga Point littoral site, data from quadrates (1/300m^2).

Continued on next page.

Appendix 2a. Continued. Upper Bay of Quinte 2000.

Big Bay			**Total *Dreissena***		**Zebra Mussels**		**Quagga Mussels**		**Plants**
Station	Depth	Sample	Density	Biomass	Density	Biomass	Density	Biomass	Biomass
Big Island-2	2	D-1	2615	316.67	2615	316.67	0	0.00	na
Big Island-2	2	D-2	6504	545.04	6504	545.04	0	0.00	na
Big Island-2	2	D-5	11370	1457.27	11370	1457.27	0	0.00	na
Big Island-2	2	D-9	2979	381.64	2979	381.64	0	0.00	na
Big Island-2	2	D10	565	73.39	565	73.39	0	0.00	na
Big Island-3	3	D-1	23360	1960.00	23360	1960.00	0	0.00	na
Big Island-3	3	D-2	40800	5516.47	40800	5516.47	0	0.00	na
Big Island-3	3	D-5	18410	2011.10	18410	2011.10	0	0.00	na
Big Island-3	3	D-9	12030	1150.50	12030	1150.50	0	0.00	na
Big Island-3	3	D10	75176	4728.34	75176	4728.34	0	0.00	na
Big Island-3.4	3.4	D-1	39240	5316.30	39150	5256.90	90	59.40	na
Big Island-3.4	3.4	D-2	47247	7221.77	47110	7129.10	137	92.67	na
Big Island-3.4	3.4	D-5	103320	13549.50	103230	13514.40	90	35.10	na
Big Island-3.4	3.4	D-9	112480	12898.40	112480	12898.40	0	0.00	na
Big Island-3.4	3.4	D10	255108	27521.10	254785	27228.07	323	293.03	na
Muscote Bay	2	D-1	5483	705.63	5483	705.63	0	0.00	na
Muscote Bay	2	D-2	0	0.00	0	0.00	0	0.00	na
Muscote Bay	2	D-5	2900	534.00	2900	534.00	0	0.00	na
Muscote Bay	2	D-9	3794	457.59	3794	457.59	0	0.00	na
Muscote Bay	2	D10	641	76.90	641	76.90	0	0.00	na
Trident Point	2.4	D-1	53960	3415.25	53960	3415.25	0	0.00	na
Trident Point	2.4	D-2	84503	5197.72	84503	5197.72	0	0.00	na
Trident Point	2.4	D-5	105600	7894.50	105600	7894.50	0	0.00	na
Trident Point	2.4	D-9	76000	9709.00	76000	9709.00	0	0.00	na
Trident Point	2.4	D10	140220	11408.55	140220	11408.55	0	0.00	na
U14-01*	1	1	35225	3751.10	35225	3751.10	0	0.00	na
U14-02	2	1	135	3.31	23580	310.14	0	0.00	332.0
U14-02	2	2	23940	2943.54	96030	1259.15	0	0.00	512.9
U14-02	3	1	64620	4320.63	64620	4320.63	0	0.00	52.0
U14-02	3	2	70965	5609.07	70965	5609.07	0	0.00	0.0
U14-03	4.3	1	135	3.31	135	3.31	0	0.00	0.0
U14-03	4.3	2	23940	2943.54	23940	2943.54	0	0.00	0.0
n=	32	**Ave.**	45102	4488.16	48067	4430.10	20	15.01	128.1
		S.E.	9730	1011.93	9738	1007.25	11	9.63	78.8

* Big Bay littoral site, data from quadrates (1/300m^2).

Appendix 2b. Middle Bay of Quinte 2000. *Dreissena* spp. density (no./m^2) and biomass (g/m^2 wet weight with shells) for mussels retained on 1 mm mesh and macrophyte biomass (g/m^2 wet weight). All data from the Ponar and dive samples are included, depth =(m), D = dive, na = not available.

Napanee			**Total *Dreissena***		**Zebra Mussels**		**Quagga Mussels**		**Plants**
Station	Depth	Sample	Density	Biomass	Density	Biomass	Density	Biomass	Biomass
Foresters Island	3	D-1	76209	6743.10	76209	6743.10	0	0.0	na
Foresters Island	3	D-2	5790	978.90	5730	962.40	60	16.5	na
Foresters Island	3	D-5	15250	6462.00	15200	6453.00	50	9.0	na
Foresters Island	3	D-9	2030	796.10	2030	796.10	0	0.0	na
Foresters Island	3	D10	7700	3274.50	7600	3244.50	100	30.0	na
Hogs Back	3	D-1	36750	2567.10	36240	2177.70	510	389.4	na
Hogs Back	3	D-2	24270	2166.00	24060	2040.00	210	126.0	na
Hogs Back	3	D-5	75850	5786.00	75200	4971.50	650	814.5	na
Hogs Back	3	D-9	38480	10922.40	36640	8507.20	1840	2415.2	na
Hogs Back	3	D10	20700	10122.60	19500	8918.40	1200	1204.2	na
Foresters Island	3	1	9315	1049.85	8910	1019.43	405	30.4	0.00
Foresters Island	3	2	155700	5196.42	155700	5196.42	0	0.0	3688.07
Foresters Island	4	1	9090	2753.15	9000	2741.45	90	11.7	0.00
Foresters Island	8.5	1	135	0.14	135	0.14	0	0.0	0.00
Foresters Island	8.5	2	45	0.36	45	0.36	0	0.0	0.00
Napanee S.E.	2	1	303435	2277.27	303435	2277.27	0	0.0	2880.50
Napanee S.E.	2	2	74205	762.35	74205	762.35	0	0.0	867.42
Napanee S.E.	3.6	1	90	0.57	90	0.57	0	0.0	0.00
Napanee S.E.	3.6	2	0	0.00	0	0.00	0	0.0	0.00
Napanee Buoy	4.8	1	0	0.00	0	0.00	0	0.0	0.00
Napanee Buoy	4.8	2	270	0.58	270	0.58	0	0.0	0.00
Unger Point	2	1	16110	595.24	16110	595.24	0	0.0	13.89
Unger Point	3	1	0	0.00	0	0.00	0	0.0	0.00
Unger Point	3	2	11295	894.51	11295	894.51	0	0.0	0.00
Unger Point	4.1	1	0	0.00	0	0.00	0	0.0	0.00
n=	25	**Ave.**	35309	2533.96	35104	2332.09	205	201.9	496.66
		S.E.	13351	643.10	13352	564.57	88	108.8	300.41

Hay Bay									
Station	Depth	Sample	Density	Biomass	Density	Biomass	Density	Biomass	Biomass
Hay Bay Buoy	11.1	1	0	0.00	0	0.00	0	0.0	0.00
Hay Bay Buoy	11.1	2	0	0.00	0	0.00	0	0.0	0.00
HB North Shore	2.1	1	3915	166.19	3285	35.69	630	130.5	130.10
HB North Shore	2.1	2	53280	2015.97	47520	451.67	5760	1564.3	1288.26
HB North Shore	4	1	301365	7712.98	266625	2071.44	34740	5641.5	2113.43
HB North Shore	4	2	765	3.36	765	3.36	0	0.0	17.28
HB North Shore	5	1	2655	2381.31	2025	994.95	630	1386.4	0.00
HB North Shore	5	2	8730	8288.54	4320	1666.52	4410	6622.0	0.00
HB West Shore	2	1	7380	7331.94	4590	3917.43	2790	3414.5	0.00
HB West Shore	2	2	13365	6316.53	10305	2597.67	3060	3718.9	338.63
HB West Shore	4	1	9495	8475.92	3600	1343.90	5895	7132.0	0.00
HB West Shore	4	2	1755	1077.03	1305	566.28	450	510.8	0.00
HB West Shore	12.4	1	0	0.00	0	0.00	0	0.0	0.00
HB West Shore	12.4	2	0	0.00	0	0.00	0	0.0	0.00
n=	14	**Ave.**	28765	3126.41	24596	974.92	4169	2151.5	277.69
		S.E.	21291	960.10	18906	324.61	2424	710.5	168.68

Appendix 2c. Lower Bay of Quinte 2000. *Dreissena* spp. density (no./m^2) and biomass (g/m^2 wet weight with shells) for mussels retained on 1 mm mesh and macrophyte biomass (g/m^2 wet weight). All data from the Ponar and dive samples are included, depth =(m), D = dive, na = not available.

Glenora			**Total *Dreissena***		**Zebra Mussels**		**Quagga Mussels**		**Plants**
Station	Depth	Sample	Density	Biomass	Density	Biomass	Density	Biomass	Biomass
Glenora-3	3.0	D-1	163530	8329.50	127710	1800.90	35820	6528.6	na
Glenora-3	3.0	D-2	58380	7043.40	33600	636.60	24780	6406.8	na
Glenora-3	3.0	D-5	30960	5913.00	8640	400.50	22320	5512.5	na
Glenora-3	3.0	D-9	65120	9110.40	11520	647.20	53600	8463.2	na
Glenora-3	3.0	D10	137970	11107.80	73260	2262.60	64710	8845.2	na
Glenora-8	8.0	D-1	18360	1932.30	180	4.50	18180	1927.8	na
Glenora-8	8.0	D-2	28960	7340.00	80	71.20	28880	7268.8	na
Glenora-8	8.0	D-5	21040	8928.80	240	2.40	20800	8926.4	na
Glenora-8	8.0	D-9	70585	19195.04	0	0.00	70585	19194.8	na
Glenora-8	8.0	D10	39615	12202.55	0	0.00	39615	12201.8	na
Glen. Dive 8	8	1	21690	6002.46	0	0.00	21690	6002.3	0.00
Glen. Dive 8	8	2	55260	10778.34	0	0.00	55260	10778.3	134.01
Glenora Buoy	20	1	0	0.00	0	0.00	0	0.0	0.00
Glenora Buoy	20	2	0	0.00	0	0.00	0	0.0	0.00
T-4D	8.9	1	28305	5851.71	0	0.00	28305	5851.7	0.00
T-4D	8.9	2	28845	6823.98	270	4.64	28575	6819.3	0.00
T-4E	15	1	24210	4831.25	45	1.13	24165	4830.1	0.00
T-4E	15	2	8100	1672.63	45	0.12	8055	1672.5	0.00
T-4F	5	1	19080	2747.66	3690	85.55	15390	2662.1	101.84
T-4F	5	2	25830	2830.73	4005	58.32	21825	2772.4	121.82
T-7D	15.2	1	6615	1428.30	90	87.57	6525	1340.7	0.00
T-7D	15.2	2	8820	1051.53	0	0.00	8820	1051.5	0.00
T-7E	8.2	1	13140	1283.90	45	23.27	13095	1260.6	0.00
T-7E	8.2	2	17145	1643.85	45	0.14	17100	1643.7	0.00
T-7G	9	1	21105	7272.68	0	0.00	21105	7272.7	0.00
T-7G	9	2	19530	7175.06	45	0.82	19485	7174.2	0.00
n=	26	**Ave.**	35854	5865.26	10135	234.13	25719	5631.1	22.35
		S.E.	7584	883.32	5598	110.56	3578	857.9	12.11

Continued on next page.

Appendix 2c. Continued. Lower Bay of Quinte 2000.

C o n w a y			Total *Dreissena*		Zebra Mussels		Quagga Mussels		Plants
Station	Depth	Sample	Density	Biomass	Density	Biomass	Density	Biomass	Biomass
Conway-3	3	D-1	4420	188.70	1570	30.30	2850	158.4	na
Conway-3	3	D-2	11040	281.10	8010	96.80	3030	184.3	na
Conway-3	3	D-5	4420	193.50	1560	29.10	2860	164.4	na
Conway-3	3	D-9	4560	221.40	1860	31.40	2700	190.0	na
Conway-3	3	D10	6350	224.20	3060	59.30	3290	164.9	na
Conway-8	8	D-1	44400	9011.00	0	0.00	44400	9011.0	na
Conway-8	8	D-2	21500	9304.00	3200	352.00	18300	8952.0	na
Conway-8	8	D-5	81200	9787.00	0	0.00	81200	9787.0	na
Conway-8	8	D-9	48500	8564.00	0	0.00	48500	8564.0	na
Conway-8	8	D10	61400	13131.00	0	0.00	61400	13131.0	na
Indian Point-3	3	D-1	55600	6568.00	11400	312.00	44200	6256.0	na
Indian Point-3	3	D-2	28300	4105.00	9000	543.00	19300	3562.0	na
Indian Point-3	3	D-5	38400	5394.00	13700	254.00	24700	5140.0	na
Indian Point-3	3	D-9	15300	4014.00	4600	175.00	10700	3839.0	na
Indian Point-3	3	D10	52200	9653.00	23800	808.00	28400	8845.0	na
Indian Point-8	8	D-1	16100	8726.40	3100	294.00	13000	8432.4	na
Indian Point-8	8	D-2	43900	8524.00	0	0.00	43900	8524.0	na
Indian Point-8	8	D-5	29900	12997.00	1800	197.00	28100	12800.0	na
Indian Point-8	8	D-9	22100	7666.00	700	53.00	21400	7613.0	na
Indian Point-8	8	D10	17200	8943.00	500	73.00	16700	8870.0	na
T-9D	21	1	900	480.51	0	0.00	900	480.5	0.00
T-9D	21	2	450	265.16	0	0.00	450	265.2	0.00
T-9E	9.9	1	31095	4008.02	0	0.00	31095	4008.0	0.00
T-9E	9.9	2	37305	4801.55	0	0.00	37305	4801.5	0.00
T-9F	8.1	1	1170	320.81	0	0.00	1170	320.8	0.00
T-9F	8.1	2	2025	455.06	0	0.00	2025	455.1	0.00
Conway Buoy	33	1	0	0.00	0	0.00	0	0.0	0.00
Conway Buoy	33	2	405	164.16	0	0.00	405	164.2	0.00
Conway Dive-3	3.3	1	20565	167.18	14760	84.15	5805	83.0	1504.40
Conway Dive-3	3.3	2	585	13.85	180	1.41	405	12.4	167.22
Conway Dive-8	7.8	1	15885	4268.70	0	0.00	15885	4268.7	0.00
Conway Dive-8	7.8	2	26145	6461.60	0	0.00	26145	6461.6	0.00
Conway Dive-15	15.9	1	6795	1636.38	180	9.09	6615	1627.3	0.00
Conway Dive-15	15.9	2	9945	4345.26	270	55.95	9675	4289.3	0.00
T-11D	19.8	1	225	60.84	0	0.00	225	60.8	0.00
T-11D	19.8	2	1980	644.87	225	138.04	1755	506.8	0.00
T-11F	10.5	1	26685	5809.76	45	1.88	26640	5807.9	0.00
T-11F	10.5	2	13635	2698.88	0	0.00	13635	2698.9	0.00
T-11H	7	1	26460	7049.16	0	0.00	26460	7049.2	0.00
T-11H	7	2	21105	4892.13	45	4.28	21060	4887.9	0.00
T-13C	21.5	1	1890	780.93	45	81.81	1845	699.1	0.00
T-13C	21.5	2	1215	250.12	0	0.00	1215	250.1	0.00
T-13F	21.6	1	5445	3077.24	270	326.12	5175	2751.1	0.00
T-13F	21.6	2	585	292.68	0	0.00	585	292.7	0.00
T-13G	16.3	1	28215	5795.33	45	3.29	28170	5792.0	0.00
T-13G	16.3	2	35685	6569.10	0	0.00	35685	6569.1	0.00
n=	46	**Ave.**	20069	4191.42	2259	87.26	17810	4104.2	64.29
		S.E.	2870	573.00	721	24.13	2742	566.5	57.96

Appendix 3a. Zebra mussel size frequency in the Upper Bay of Quinte for 2000 by density (no./mini Ponar) and biomass (g/mini Ponar wet weight with shells). Data from replicates where mussels present and size frequencies analyzed. The data from dive (D) samples are listed as Ponar equivalence, depth = (m).

			Zebra Mussels Size Frequency - Density /Area							Zebra Mussels Biomass - Size Frequency/Ponar						
Station Site	Depth	Ponar	<5	5-10	10-15	15-20	20-25	25+	Sum	<5	5-10	10-15	15-20	20-25	25+	Sum
Upper Bay																
Big Island	2.0	D-1	19	21	10	6	1	1	58.1	0.12	0.91	1.85	2.38	0.47	1.31	7.04
Big Island	2.0	D-5	118	69	29	30	7	0	252.7	1.03	3.42	6.35	14.77	6.80	0.00	32.37
Big Island	3.0	D-1	257	148	82	30	2	0	519.1	3.47	7.22	17.39	14.40	1.08	0.00	43.56
Big Island	3.4	D-1	618	128	30	34	48	12	870.0	5.72	5.76	5.90	21.00	56.96	21.48	116.82
Indian Island	2.5	D-1	189	19	6	14	4	0	232.2	0.94	0.64	1.34	7.20	4.57	0.00	14.70
Makatewis Shoal	3.0	D-1	9	124	77	70	49	0	328.7	0.09	7.42	15.64	48.32	51.93	0.00	123.40
Muscote Bay	2.0	D-1	19	30	66	6	0	0	121.8	0.05	2.02	11.19	2.42	0.00	0.00	15.68
Trident Point	2.4	D-1	871	188	106	11	17	6	1199.1	8.21	16.13	17.18	5.13	20.48	8.76	75.89
U1-01	1.5	2	14	2	0	0	0	0	16	0.05	0.03	0.00	0.00	0.00	0.00	0.08
U1-02	2.5	1	45	38	0	0	0	0	83	0.35	1.05	0.00	0.00	0.00	0.00	1.41
U1-02	2.5	2	507	38	1	0	0	0	546	2.37	0.92	0.13	0.00	0.00	0.00	3.42
U1-03	3.2	1	1	0	0	0	0	0	1	0.01	0.00	0.00	0.00	0.00	0.00	0.01
U1-05	2.0	1	2,848	186	43	26	6	0	3,109	20.16	6.80	7.89	13.14	5.23	0.00	53.21
U1-05	2.0	2	1,568	167	73	21	15	2	1,846	7.25	7.07	13.47	11.30	16.53	3.08	58.70
U1-05	3.6	2	1	0	0	0	0	0	1	0.002	0.00	0.00	0.00	0.00	0.00	0.002
U2-01	2.0	1	615	88	1	0	0	0	704	4.13	2.40	0.11	0.00	0.00	0.00	6.64
U2-01	2.0	2	3,551	262	2	0	0	0	3,815	14.56	7.35	0.38	0.00	0.00	0.00	22.29
U2-01	3.8	2	4	2	0	0	0	0	6	0.02	0.05	0.00	0.00	0.00	0.00	0.07
U2-02	3.8	1	1	0	0	0	0	0	1	0.01	0.00	0.00	0.00	0.00	0.00	0.01
U2-02	3.8	2	14	0	0	0	0	0	14	0.04	0.00	0.00	0.00	0.00	0.00	0.04
U2-05	2.7	1	14	0	1	0	0	0	15	0.05	0.00	0.24	0.00	0.00	0.00	0.30
U2-05	2.7	2	13	2	1	0	0	0	16	0.05	0.06	0.20	0.00	0.00	0.00	0.31
U2-06	2.1	1	0	0	3	1	0	0	4	0.00	0.00	0.37	0.48	0.00	0.00	0.85
U2-06	2.1	2	3	3	19	7	1	0	33	0.01	0.18	3.93	2.97	0.90	0.00	7.98
U3-01	2.0	1	0	0	7	4	0	0	11	0.00	0.00	1.40	1.69	0.00	0.00	3.09
U3-07	3.5	2	10	0	0	0	0	0	10	0.03	0.00	0.00	0.00	0.00	0.00	0.03
U4-01*	1.0	1	143	187	627	143	0	0	1,099.6	0.75	10.09	110.64	55.60	0.00	0.00	177.08

* Massassauga Point, Big Bay and Oderdonk Point littoral sites, data from quadrates (1/300m^2).

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Appendix 3a. Continued. Zebra mussel size frequency in the Upper Bay of Quinte for 2000.

			Zebra Mussels Size Frequency - Density /Ponar							Zebra Mussels Biomass - Size Frequency/Ponar						
Station Site	Depth	Ponar	<5	5-10	10-15	15-20	20-25	25+	Sum	<5	5-10	10-15	15-20	20-25	25+	Sum
Upper Bay																
U4-01	2.0	1	95	22	2	1	0	0	120	0.44	0.50	0.34	0.61	0.00	0.00	1.89
U4-01	2.0	2	6,577	372	12	1	0	0	6,962	28.28	10.15	2.43	0.27	0.00	0.00	41.13
U4-01	3.0	1	197	11	0	0	0	0	208	0.62	0.22	0.00	0.00	0.00	0.00	0.84
U4-01	3.0	2	17	1	0	0	0	0	18	0.05	0.03	0.00	0.00	0.00	0.00	0.08
U9-01	4.0	1	0	5	3	0	0	2	10	0.00	0.32	0.61	0.00	0.00	2.91	3.84
U9-01	4.0	2	24	65	70	20	17	3	199	0.33	3.78	14.20	12.50	22.99	7.28	61.07
U9-03	4.6	2	2	0	0	0	0	0	2	0.01	0.00	0.00	0.00	0.00	0.00	0.01
U9-08	3.0	1	508	721	179	34	20	2	1,464	4.71	38.53	31.27	20.04	20.05	3.63	118.23
U9-08	3.0	2	320	862	310	75	38	6	1,611	2.27	34.87	46.22	37.47	36.75	9.40	166.97
U10-01*	1.0	1	239	533	250	65	0	0	1087.3	1.98	26.39	39.78	26.11	0.00	0.00	94.26
U10-01	2.0	1	478	475	52	79	38	3	1,125	3.45	18.57	10.17	51.51	40.08	4.68	128.45
U10-01	2.0	2	386	562	47	28	22	1	1,046	3.47	27.04	8.33	17.15	23.85	1.68	81.51
U10-02	3.0	1	839	464	48	73	51	6	1,481	6.33	18.20	8.07	44.97	55.35	8.78	141.71
U10-02	3.0	2	661	526	76	42	49	2	1,356	4.19	17.30	12.42	19.79	49.26	3.55	106.51
U10-07	4.0	1	5	0	0	0	0	0	5	0.03	0.00	0.00	0.00	0.00	0.00	0.03
U10-08	2.0	1	9,412	247	66	7	2	0	9,734	52.71	14.16	11.33	2.92	1.74	0.00	82.85
U10-08	2.0	2	472	160	23	21	8	0	684	2.16	4.58	4.85	11.92	7.18	0.00	30.69
U14-01**	1.0	1	149	469	125	16	16	8	782.8	1.27	18.09	17.42	10.34	17.17	19.08	83.36
U14-02	2.0	1	441	76	7	0	0	0	524	3.08	2.80	1.01	0.00	0.00	0.00	6.89
U14-02	2.0	2	1,649	462	17	5	1	0	2,134	7.89	13.15	2.96	2.91	1.07	0.00	27.98
U14-02	3.0	1	1,034	273	59	34	31	5	1,436	5.95	10.47	12.70	20.76	37.74	8.40	96.01
U14-02	3.0	2	938	474	74	33	46	12	1,577	5.70	14.65	13.90	17.56	51.23	21.62	124.65
U14-03	4.3	1	1	2	0	0	0	0	3	0.00	0.07	0.00	0.00	0.00	0.00	0.07
U14-03	4.3	2	112	260	111	32	15	2	532	0.90	12.50	18.66	13.33	16.71	3.32	65.41

* Big Bay littoral sites, data from quadrates (1/300m^2).

** Oderdonk Point littoral sites, data from quadrates (1/300m^2).

Appendix 3b. Zebra mussel size frequency in the Middle Bay of Quinte for 2000 by density (no./mini Ponar) and biomass (g/mini Ponar wet weight with shells). Data from replicates where mussels present and size frequencies analyzed. Data from dive (D) samples are listed as Ponar equivalence. depth = (m).

			Zebra Mussels Size Frequency - Density /Ponar							Zebra Mussels Biomass - Size Frequency/Ponar						
Station Site	Depth	Ponar	<5	5-10	10-15	15-20	20-25	25+	Sum	<5	5-10	10-15	15-20	20-25	25+	Sum
Middle Bay																
Foresters Island	3.0	1	124	26	16	30	2	0	198	0.60	0.98	3.74	15.60	1.74	0.00	22.65
Foresters Island	3.0	2	2,881	409	48	69	50	3	3,460	12.02	11.81	8.25	37.78	41.97	3.65	115.48
Foresters Island	4.0	1	77	25	24	45	27	2	200	0.40	1.01	4.82	26.75	25.71	2.24	60.92
Foresters Island	8.5	1	3	0	0	0	0	0	3	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Foresters Island	8.5	2	1	0	0	0	0	0	1	0.01	0.00	0.00	0.00	0.00	0.00	0.01
Hay Bay North	2.1	1	54	19	0	0	0	0	73	0.25	0.54	0.00	0.00	0.00	0.00	0.79
Hay Bay North	2.1	2	882	154	19	1	0	0	1,056	2.95	3.97	2.85	0.27	0.00	0.00	10.04
Hay Bay North	4.0	1	5,546	359	16	4	0	0	5,925	29.46	12.00	3.34	1.23	0.00	0.00	46.03
Hay Bay North	4.0	2	17	0	0	0	0	0	17	0.07	0.00	0.00	0.00	0.00	0.00	0.07
Hay Bay North	5.0	1	13	14	6	4	3	5	45	0.08	0.71	1.49	2.24	3.96	13.64	22.11
Hay Bay North	5.0	2	16	28	12	21	14	5	96	0.09	0.80	2.77	11.54	14.24	7.59	37.03
Hay Bay West	2.0	1	24	13	19	22	18	6	102	0.27	0.85	6.63	20.64	41.56	17.11	87.05
Hay Bay West	2.0	2	39	29	95	55	9	2	229	0.13	1.84	17.36	24.95	9.58	3.87	57.73
Hay Bay West	4.0	1	3	0	40	36	1	0	80	0.03	0.00	10.53	18.35	0.96	0.00	29.86
Hay Bay West	4.0	2	0	0	8	19	2	0	29	0.00	0.00	1.55	9.54	1.49	0.00	12.58
Napanee Buoy	4.8	2	5	1	0	0	0	0	6	0.01	0.01	0.00	0.00	0.00	0.00	0.01
Napanee S.E.	2.0	1	5,929	758	54	2	0	0	6,743	21.27	19.89	8.62	0.83	0.00	0.00	50.61
Napanee S.E.	2.0	2	1,405	212	30	2	0	0	1,649	4.86	6.66	4.69	0.73	0.00	0.00	16.94
Napanee S.E.	3.6	1	2	0	0	0	0	0	2	0.01	0.00	0.00	0.00	0.00	0.00	0.01
Napanee S.E.	3.6	2	0	0	0	0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Unger Point	2.0	1	178	155	22	3	0	0	358	0.99	6.82	4.09	1.33	0.00	0.00	13.23
Unger Point	3.0	2	118	100	19	8	4	2	251	0.73	4.03	2.82	4.08	4.05	4.18	19.88
Foresters Island	3.0	D-1	779	591	168	121	35	0	1693.5	6.95	21.58	29.05	57.84	34.43	0.00	149.85
Hogs Back	3.0	D-1	561	143	58	38	5	0	805.3	4.23	6.67	11.89	20.07	5.54	0.00	48.39

Appendix 3c. Zebra mussel size frequency in the Lower Bay of Quinte for 2000 by density (no./mini Ponar) and biomass (g/mini Ponar wet weight with shells). Data from replicates where mussels present and size frequencies analyzed. Data from dive (D) samples are listed as Ponar equivalence, depth = (m).

			Zebra Mussels Size Frequency - Density /Ponar							Zebra Mussels Biomass - Size Frequency/Ponar						
Station Site	Depth	Ponar	<5	5-10	10-15	15-20	20-25	25+	Sum	<5	5-10	10-15	15-20	20-25	25+	Sum
Lower Bay																
T-4D	8.9	2	3	3	0	0	0	0	6	0.01	0.10	0.00	0.00	0.00	0.00	0.10
T-4E	15.0	1	0	1	0	0	0	0	1	0.00	0.03	0.00	0.00	0.00	0.00	0.03
T-4E	15.0	2	1	0	0	0	0	0	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-4F	5.0	1	59	18	5	0	0	0	82	0.34	0.70	0.86	0.00	0.00	0.00	1.90
T-4F	5.0	2	70	17	2	0	0	0	89	0.29	0.74	0.27	0.00	0.00	0.00	1.30
T-7D	15.2	1	1	0	0	0	0	1	2	0.01	0.00	0.00	0.00	0.00	1.94	1.95
T-7E	8.2	1	0	0	0	1	0	0	1	0.00	0.00	0.00	0.52	0.00	0.00	0.52
T-7E	8.2	2	1	0	0	0	0	0	1	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T-7G	9.0	2	1	0	0	0	0	0	1	0.02	0.00	0.00	0.00	0.00	0.00	0.02
T-11D	19.8	2	1	1	0	2	0	1	5	0.00	0.04	0.00	1.07	0.00	1.95	3.07
T-11F	10.5	1	0	1	0	0	0	0	1	0.00	0.04	0.00	0.00	0.00	0.00	0.04
T-11H	7.0	2	0	1	0	0	0	0	1	0.00	0.10	0.00	0.00	0.00	0.00	0.10
T-13C	21.5	1	0	0	0	0	0	1	1	0.00	0.00	0.00	0.00	0.00	1.82	1.82
T-13F	21.6	1	0	0	0	2	4	0	6	0.00	0.00	0.00	1.12	6.12	0.00	7.25
T-13G	16.3	1	0	1	0	0	0	0	1	0.00	0.07	0.00	0.00	0.00	0.00	0.07
Conway Dive 3m	3.3	1	304	23	1	0	0	0	328	0.85	0.83	0.18	0.00	0.00	0.00	1.87
Conway Dive 3m	3.3	2	2	2	0	0	0	0	4	0.01	0.02	0.00	0.00	0.00	0.00	0.03
Conway Dive 15m	15.9	1	1	2	1	0	0	0	4	0.00	0.06	0.14	0.00	0.00	0.00	0.20
Conway Dive 15m	15.9	2	0	5	0	0	1	0	6	0.00	0.06	0.00	0.00	1.18	0.00	1.24
Conway	3.0	D-1	27	7	1	0	0	0	34.9	0.13	0.36	0.18	0.00	0.00	0.00	0.67
Conway	8.0	D-2	2	47	22	0	0	0	71.1	0.09	3.51	4.22	0.00	0.00	0.00	7.82
Glenora	3.0	D-1	2574	186	76	2	0	0	2838.0	10.80	7.88	19.98	1.36	0.00	0.00	40.02
Glenora	8.0	D-1	0	4	0	0	0	0	4.0	0.00	0.10	0.00	0.00	0.00	0.00	0.10
Glenora	8.0	D-2	0	0	0	0	2	0	1.8	0.00	0.00	0.00	0.00	1.58	0.00	1.58
Glenora	8.0	D-5	4	2	0	0	0	0	5.3	0.02	0.04	0.00	0.00	0.00	0.00	0.05
Indian Point	3.0	D-1	150	87	16	0	0	0	253.3	0.82	3.13	2.98	0.00	0.00	0.00	6.93
Indian Point	3.0	D-5	0	31	9	0	0	0	40.0	0.00	2.64	1.73	0.00	0.00	0.00	4.38
Indian Point	3.0	D-9	2	14	0	0	0	0	15.6	0.02	1.16	0.00	0.00	0.00	0.00	1.18
Indian Point	3.0	D10	0	4	7	0	0	0	11.1	0.40	1.22	0.00	0.00	0.00	0.00	1.62
Indian Point	8.0	D-1	0	44	24	0	0	0	68.8	0.00	3.11	3.42	0.00	0.00	0.00	6.53

Appendix 4a. Quagga mussel size frequency in the Upper Bay of Quinte for 2000 by density (no./mini Ponar) and biomass (g/mini Ponar wet weight with shells). Data from replicates where mussels present and size frequencies analyzed. To allow comparison with Ponar samples, data from dive (D) samples are listed as mini Ponar equivalent area ($0.0225m^2$), depth = (m).

			Quagga Mussels Size Frequency - Density /Ponar							**Quagga Mussels Biomass - Size Frequency/Ponar**						
Station Site	Depth	Ponar	<5	5-10	10-15	15-20	20-25	25+	Sum	<5	5-10	10-15	15-20	20-25	25+	Sum
Upper Bay																
U9-08	3.0	1	0	0	0	4	3	0	7	0.00	0.00	0.00	2.06	2.90	0.00	4.96
U9-08	3.0	2	8	2	0	8	3	0	21	0.07	0.05	0.00	5.32	3.23	0.00	8.66
U10-01	2.0	1	0	0	0	2	1	0	3	0.00	0.00	0.00	1.17	0.87	0.00	2.04
U10-02	3.0	1	0	0	0	0	1	0	1	0.00	0.00	0.00	0.00	0.97	0.00	0.97
U10-02	3.0	2	0	0	0	0	1	0	1	0.00	0.00	0.00	0.00	0.97	0.00	0.97
Big Island	3.4	D-1	0	0	0	2	0	0	2.0	0.00	0.00	0.00	1.32	0.00	0.00	1.32
Big Island	3.4	D-2	0	0	0	1	2	0	3.0	0.00	0.00	0.00	0.50	1.56	0.00	2.06
Big Island	3.4	D-5	0	0	0	2	0	0	2.0	0.00	0.00	0.00	0.78	0.00	0.00	0.78
Big Island	3.4	D10	0	0	0	0	7	0	7.2	0.00	0.00	0.00	0.00	6.51	0.00	6.51
Makatewis Shoal	3.0	D-1	0	0	0	2	0	2	3.8	0.00	0.00	0.00	1.47	0.00	2.68	4.16
Makatewis Shoal	3.0	D-2	0	0	0	2	0	2	3.8	0.00	0.00	0.00	1.25	0.00	3.59	4.84
Makatewis Shoal	3.0	D-5	0	0	0	0	0	1	0.5	0.00	0.00	0.00	0.00	0.00	1.16	1.16
Makatewis Shoal	3.0	D10	0	0	0	0	2	0	1.9	0.00	0.00	0.00	0.00	2.63	0.00	2.63

Appendix 4b. Quagga mussel size frequency in the Middle Bay of Quinte for 2000 by density (no./mini Ponar) and biomass (g/mini Ponar wet weight with shells). Data from replicates where mussels present and size frequencies analyzed. To allow comparison with Ponar samples, data from dive (D) samples are listed as mini Ponar equivalent area ($0.0225m^2$), depth = (m).

			Quagga Mussels Size Frequency - Density /Ponar							Quagga Mussels Biomass - Size Frequency/Ponar						
Station Site	Depth	Ponar	<5	5-10	10-15	15-20	20-25	25+	Sum	<5	5-10	10-15	15-20	20-25	25+	Sum
Middle Bay																
Foresters Island	3.0	1	6	1	0	2	0	0	9	0.01	0.07	0.00	0.60	0.00	0.00	0.68
Foresters Island	4.0	1	1	0	1	0	0	0	2	0.01	0.00	0.25	0.00	0.00	0.00	0.26
Hay Bay North	2.1	1	0	2	5	6	1	0	14	0.00	0.20	0.67	1.48	0.55	0.00	2.90
Hay Bay North	2.1	2	1	16	45	60	6	0	128	0.01	0.85	7.66	22.12	4.12	0.00	34.76
Hay Bay North	4.0	1	565	23	7	101	71	5	772	1.68	0.32	1.60	56.40	59.16	6.21	125.37
Hay Bay North	5.0	1	0	0	1	2	2	9	14	0.00	0.00	0.24	0.94	2.52	27.11	30.81
Hay Bay North	5.0	2	2	8	1	0	28	59	98	0.01	0.30	0.09	0.00	36.00	110.76	147.16
Hay Bay West	2.0	1	0	3	15	12	16	16	62	0.00	0.22	3.61	6.39	24.38	41.27	75.88
Hay Bay West	2.0	2	2	2	3	9	31	21	68	0.01	0.05	0.53	5.49	38.63	37.93	82.64
Hay Bay West	4.0	1	4	0	2	16	80	29	131	0.01	0.00	0.44	10.80	97.13	50.12	158.49
Hay Bay West	4.0	2	0	2	0	1	5	2	10	0.00	0.06	0.00	0.31	7.26	3.72	11.35
Foresters Island	3.0	D-2	0	0	1	1	0	0	1.2	0.00	0.00	0.07	0.30	0.00	0.00	0.37
Foresters Island	3.0	D-5	0	0	1	0	0	0	1.1	0.00	0.00	0.20	0.00	0.00	0.00	0.20
Foresters Island	3.0	D10	0	0	1	1	0	0	2.2	0.00	0.00	0.28	0.39	0.00	0.00	0.67
Hogs Back	3.0	D-1	3	0	3	0	1	4	11.3	0.01	0.00	0.45	0.00	1.11	7.08	8.65
Hogs Back	3.0	D-2	0	0	2	2	0	1	4.7	0.00	0.00	0.48	1.14	0.00	1.18	2.80
Hogs Back	3.0	D-5	0	0	3	2	2	7	14.4	0.00	0.00	0.83	0.86	3.47	12.94	18.10
Hogs Back	3.0	D-9	0	0	5	5	9	22	40.9	0.00	0.00	0.82	1.76	11.04	40.05	53.67
Hogs Back	3.0	D10	0	0	1	17	1	8	26.7	0.00	0.00	0.25	8.24	1.36	16.91	26.76

Continued on next page.

Appendix 4c. Continued. Quagga mussel size frequency in the Middle Bay of Quinte for 2000.

			Quagga Mussels Size Frequency - Density /Ponar							Quagga Mussels Biomass - Size Frequency/Ponar						
Station Site	Depth	Ponar	<5	5-10	10-15	15-20	20-25	25+	Sum	<5	5-10	10-15	15-20	20-25	25+	Sum
Lower Bay																
T-4D	8.9	1	52	180	292	86	7	12	629	0.67	9.84	48.52	34.19	7.13	29.71	130.04
T-4D	8.9	2	20	179	307	98	11	20	635	0.16	9.67	53.63	36.98	9.34	41.77	151.54
T-4E	15.0	1	113	186	174	39	5	20	537	0.95	6.94	28.55	15.96	5.68	49.26	107.34
T-4E	15.0	2	12	33	86	42	5	1	179	0.07	1.05	12.58	15.51	4.74	3.22	37.17
T-4F	5.0	1	193	95	26	7	4	17	342	1.49	4.74	5.11	3.96	5.46	38.40	59.16
T-4F	5.0	2	210	199	42	13	8	13	485	1.61	7.74	6.73	5.35	9.64	30.55	61.61
T-7D	15.2	1	5	37	69	30	4	0	145	0.05	2.02	10.98	13.31	3.44	0.00	29.79
T-7D	15.2	2	13	69	79	34	1	0	196	0.08	2.28	10.03	10.32	0.66	0.00	23.37
T-7E	8.2	1	104	146	28	5	3	5	291	1.09	5.84	4.45	2.84	3.01	10.78	28.01
T-7E	8.2	2	104	201	62	5	2	6	380	0.85	7.02	9.38	2.15	1.64	15.49	36.53
T-7G	9.0	1	8	142	208	72	12	27	469	0.07	11.64	43.01	30.03	13.39	63.49	161.62
T-7G	9.0	2	2	44	217	132	12	26	433	0.01	2.33	41.22	50.96	13.42	51.49	159.43
T-9D	21.0	1	0	0	1	16	3	0	20	0.00	0.00	0.09	8.16	2.44	0.00	10.68
T-9D	21.0	2	2	0	0	4	4	0	10	0.01	0.00	0.00	2.22	3.67	0.00	5.89
T-9E	9.9	1	314	278	53	13	14	19	691	2.37	10.62	8.74	5.57	19.87	41.89	89.07
T-9E	9.9	2	250	417	98	23	22	19	829	1.50	13.88	13.79	10.89	25.45	41.20	106.70
T-9F	8.1	1	2	4	14	3	3	0	26	0.02	0.17	2.80	0.89	3.25	0.00	7.13
T-9F	8.1	2	1	4	29	9	0	2	45	0.01	0.15	4.32	2.54	0.00	3.10	10.11
T-11D	19.8	1	0	0	4	1	0	0	5	0.00	0.00	0.91	0.44	0.00	0.00	1.35
T-11D	19.8	2	0	5	12	20	1	1	39	0.00	0.15	1.74	7.46	0.69	1.24	11.26
T-11F	10.5	1	40	245	235	38	17	17	592	0.45	13.24	41.29	14.70	24.28	35.10	129.06
T-11F	10.5	2	19	116	129	25	2	12	303	0.13	4.94	18.33	8.71	2.55	25.33	59.98
T-11H	7.0	1	160	245	81	35	52	15	588	1.53	12.76	16.02	22.11	69.36	34.87	156.65
T-11H	7.0	2	59	214	129	27	28	11	468	0.36	9.69	21.41	13.24	37.38	26.54	108.62
T-13C	21.5	1	2	7	2	26	4	0	41	0.01	0.21	0.55	11.86	2.90	0.00	15.54
T-13C	21.5	2	1	13	4	7	2	0	27	0.00	0.48	0.31	2.90	1.87	0.00	5.56
T-13F	21.6	1	4	7	38	42	16	8	115	0.02	0.39	5.71	18.93	15.04	21.05	61.14
T-13F	21.6	2	0	0	2	8	3	0	13	0.00	0.00	0.54	3.01	2.95	0.00	6.50
T-13G	16.3	1	171	350	32	10	35	28	626	0.93	10.44	5.04	5.16	47.94	59.21	128.71
T-13G	16.3	2	306	373	33	13	24	44	793	1.93	10.99	4.78	6.29	30.67	91.33	145.98

Appendix 4d. Quagga mussel size frequency in the Lower Bay of Quinte for 2000 by density (no./mini Ponar) and biomass (g/mini Ponar wet weight with shells). Data from replicates where mussels present and size frequencies analyzed. To allow comparison with Ponar samples, data from dive (D) samples are listed as mini Ponar equivalent area ($0.0225m^2$), depth = (m).

			Quagga Mussels Size Frequency - Density /Ponar							Quagga Mussels Biomass - Size Frequency/Ponar						
Station Site	Depth	Frame	<5	5-10	10-15	15-20	20-25	25+	Sum	<5	5-10	10-15	15-20	20-25	25+	Sum
Lower Bay																
Conway Buoy	33.0	2	0	5	0	1	3	0	9	0.00	0.22	0.00	0.41	3.02	0.00	3.65
Conway Dive 3m	3.3	1	83	44	2	0	0	0	129	0.45	1.22	0.18	0.00	0.00	0.00	1.85
Conway Dive 3m	3.3	2	2	5	2	0	0	0	9	0.00	0.12	0.16	0.00	0.00	0.00	0.28
Conway Dive 8m	7.8	1	70	166	55	15	33	14	353	0.60	7.92	9.05	8.86	41.79	26.64	94.86
Conway Dive 8m	7.8	2	95	287	106	19	35	39	581	0.59	10.14	13.93	7.36	41.09	70.48	143.59
Conway Dive 15m	15.9	1	8	76	38	12	6	7	147	0.05	2.95	5.63	4.76	4.85	17.93	36.16
Conway Dive 15m	15.9	2	22	92	49	15	6	31	215	0.13	2.70	6.47	5.83	6.92	73.27	95.32
Glenora Dive 8m	8.0	1	11	63	257	131	15	5	482	0.08	3.09	44.77	55.88	13.39	16.18	133.39
Glenora Dive 8m	8.0	2	11	215	752	217	16	17	1,228	0.08	8.52	110.92	65.99	14.26	39.75	239.52
Conway	3.0	D-1	24	27	10	2	0	0	63.3	0.22	1.08	1.45	0.77	0.00	0.00	3.52
Conway	8.0	D-1	311	336	222	42	49	27	986.7	3.73	15.00	36.09	20.33	65.38	59.71	200.24
Glenora	3.0	D-1	144	134	436	80	2	0	796.0	0.82	10.04	97.66	34.86	1.70	0.00	145.08
Glenora	8.0	D-1	6	144	228	26	0	0	404.0	0.12	7.94	27.94	6.84	0.00	0.00	42.84
Indian Point	3.0	D-1	242	523	147	13	44	13	982.2	1.80	12.93	23.98	7.42	66.98	25.91	139.02
Indian Point	8.0	D-1	2	31	93	80	33	49	288.9	0.01	1.84	17.67	33.04	43.89	90.93	187.39